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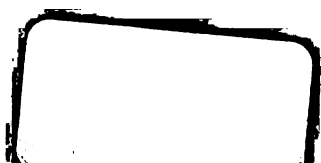
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VDA
Engineer

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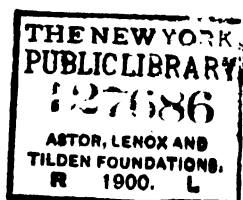
ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

PITTSBURG, PA.

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VOL. XIV.
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1898.



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OFFICERS FOR 1898.

GENERAL SOCIETY.

PRESIDENT.

G. S. DAVISON.

VICE PRESIDENTS.

H. J. LEWIS,
Term expires 1899.

W. A. BOLE,
Term expires 1900.

DIRECTORS.

J. M. CAMP,
Term expires 1899.

C. F. SCOTT,
Term expires 1900.

H. H. MCCLINTIC,
Term expires 1899.

GUSTAVE KAUFMAN,
Term expires 1900.

SECRETARY.

REGINALD A. FESSENDEN.

TREASURER.

A. E. FROST.

CHEMICAL SECTION.

CHAIRMAN.

J. O. HANDY.

VICE CHAIRMAN.

DR. WALTHER RIDDLE.

DIRECTORS.

DR. K. F. STAHL, W. E. GARRIGUES.

SECRETARY.

A. G. McKENNA.

STANDING COMMITTEES.

PROGRAMME COMMITTEE.

H. W. FISHER, Chairman, RICHARD HIRSCH,
GUSTAVE KAUFMAN, E. S. MCCLELLAND, J. O. HANDY.

HOUSE COMMITTEE.

JAMES K. LYONS, Chairman, A. KENNEDY ASHWORTH,
C. D. MARSHALL, CHARLES W. RIDINGER, J. A. ATWOOD.

LIBRARY COMMITTEE.

CHESTER B. ALBREE, Chairman, RALPH CROOKER, JR.,
G. E. FLANAGAN, W. A. BOLE, L. J. HOHL.

RECEPTION COMMITTEE.

VICTOR BEUTNER, Chairman, H. L. BARTON,
H. H. ROUSSEAU, G. L. PECK, RAWDON EVANS,
CHARLES G. SCHADE, I. W. FRANK, W. E. GARRIGUES.

PAST PRESIDENTS.

Wm. Metcalf,	1880-1.	W. L. Scaife,	1890.
A. Gottlieb,	1882-3.	T. P. Roberts,	1891.
Wm. Miller,	1884.	Alfred E. Hunt,	1892.
Geo. H. Browne,	1885.	M. J. Becker,	1893.
E. B. Taylor,	1886.	T. H. Johnson,	1894.
Alex. Dempster,	1887-8.	Chas. Davis,	1895.
J. A. Brashear,	1889.	W. G. Wilkins,	1896.
Emil Swensson, 1897.			

PAST SECRETARIES.

James H. Harlow,	1880-2-3-4.	James H. Harlow,	1891.
W. F. Zimmerman,	1885.	R. N. Clark,	1892-3.
S. M. Wickersham,	1886-7-8-9-1890.	Daniel Carhart,	1894-5-6.
Reginald A. Fessenden, 1897.			

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

LIST OF MEMBERS.

JULY 1, 1898.

Members are particularly requested to keep the Secretary constantly informed as to their correct addresses.

HONORARY MEMBERS.

Name.	Occupation and Address.	Date of Election.
LANGLEY, J. W.,	Prof of E. E. Case School of Applied Science, 77 Cornell St., Cleveland, Ohio.	M., Nov., 1888. H., M., May 1893.
THOMPSON, BEN,	Asst. Eng. Southern Ry. Co., Highland Park, Tenn.	H. M., May 1893.

MEMBERS.

(Names of Past Presidents are in Italics.)

Name.	Occupation and Address.	Date of Election.
ABBOTT, W. L.,	Manufacturer, Rm. 302 Bank of Com. Bldg., 543 Wood St., Pittsburg, Pa.	Dec., 1890.
AIKEN, HENRY,	Consulting Mechanical Engineer, 403 Lewis Block, Pittsburg, Pa.	May, 1880.
ALBREE, CHESTER B.,	Manufacturer, 16-30 Market St., Allegheny, Pa.	Oct., 1885.
ANDERSON, JOHN W.,	Gen. Mgr. Carbon Steel Co., Pittsburg, Pa. 45 Fremont St., Allegheny, Pa.	Dec., 1884.
ARMS, WALTER F.,	Supt. Eleanora Mines of the Rochester and Pittsburg Coal and Iron Co., Eleanora, Jefferson Co., Pa.	Jan., 1897.
ARMSTRONG, H. W.,	Gen. Mgr. Verona Tool Works, Verona, Pa.	Jan., 1880.
ARRAS, JOHN W.,	U. S. Asst. Engineer, Federal Building, P. O. Box 485, Pittsburg, Pa.	Nov., 1888.

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Name.	Occupation and Address.	Date of Election.
ARROTT, JR., JAMES W.,	Supt. Enameling Dept., Standard Mfg. Co. 581 Preble Ave., Allegheny, Pa.	March, 1892.
ASCHMAN, FREDERICK T.,	Analytical and Consulting Chemist, Prof. of Chemistry, Pittsburg College of Pharmacy, W. U. of Penna., Chemist of Dept. of Agriculture of Penna., 203 Water St., Pittsburg, Pa.	April, 1896.
ASHMEAD, FRANK M.,	Resident Engineer, A. V. Ry. Co. 11th and Pike Sts., Pittsburg, Pa.	April, 1893.
ASHWORTH, A. KENNEDY,	Consulting Mechanical Engineer and Steam Expert, 349 Lehigh Ave., Pittsburg, Pa.	Dec., 1895.
ASHWORTH, DANIEL,	Consulting Engineer and Steam Expert, 326 Fourth Ave., Pittsburg, Pa.	April, 1890.
ATWATER, R. M.,	Secy. Semet-Solvay Co., The Solvay-Process Co., Syracuse, New York.	April, 1896.
ATWOOD, JOHN A.,	Chief Engineer, P. & L. E. R., Beaver, Pa.	April, 1891.
BAILEY, CHARLES,	Chairman Reliance Steel Casting Co., Ltd., 36th St. and A. V. R. R., Pittsburg, Pa.	Sept., 1897.
BAILEY, JAMES M.,	Managing partner of Phillips, Nimick & Co., P. O. Box 872, Pittsburg, Pa.	Sept., 1884.
BAILEY, JOHN M.,	Sec'y Pittsburg Testing Laboratory, Ltd., 326 Water St., Pittsburg, Pa.	June, 1892.
BAKER, MORRIS,	Civil Engineer. 4811 Springfield Ave., Philadelphia, Pa.	Feb., 1894.
BAKEWELL, THOMAS W.,	Attorney-at-Law, Patent Attorney, Bakewell & Bakewell, Carnegie Building, Pittsburg, Pa.	May, 1884.
BALTZELL, WILL H.,	Mechanical Engineer, with Schoenberger & Co., Pittsburg, Pa.	Dec., 1892.
BARBOUR, GEO. H.,	Civil Engineer, with Carnegie Steel Co., Ltd., Keystone Bridge Works, 101 Beech St., Allegheny, Pa.	April, 1888.
BARR, LAWRENCE,	Telephone Engineer, with C. D. & P. Tel. Co., Pittsburg, Pa.	March, 1897.
BARRETT, J. C.,	Chief Chemist for The Ohio Steel Co., Youngstown, Ohio.	April, 1892.
BARTON, H. L.,	Asst. Supt. of Westinghouse Machine Co., East Pittsburg, Pa.	April, 1895.
BACHELOR, EDWIN S.,	Mgr. and Assist. Treas. Harrison Gas Coal Co., Supts. Clerk, P. R. R. Co., Rm. 3 Union Station, 703 Whitney Ave., Wilkensburg, Pa.	April, 1892.

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
BATES, ONWARD,	Engineer and Supt. Bridges & Buildings of C. M. & P. Ry., 1100 Old Colony Building, Chicago, Ills.	Nov., 1882.
BEAZELL, EDWIN H.,	Civil Engineer.	Nov., 1892.
BECKFIELD, CHARLES,	Mechanical Engineer, 130 S. Negley Ave., E. E., Pittsburg, Pa.	Jan., 1885.
BENNER, S. A.	Sales Dept. Carnegie Steel Co., Ltd., Pittsburg, Pa. Superior Ave., Allegheny, Pa.	Dec., 1895.
BENNEY, JAS.,	Supt. Philadelphia Co., Rm. 10 Westinghouse Building, Pittsburg, Pa.	Dec., 1883.
BEEG, P. T.,	Mechanical Engineer, with Carnegie Steel Co., Ltd., at Homestead Steel Works, Munhall, Pa.	Dec., 1892.
BERNARD, H. W.,	Mining Engineer and Chemist, with Carnegie Steel Co., Ltd., Pittsburg, Pa., 55 Wilson Avenue, Allegheny, Pa.	March, 1896.
BEUTNER, VICTOR,	Mechanical Engineer, Hydraulic Machinery Co., Pittsburg, Pa.	Feb., 1896.
BEYMER, H. W.,	Supt. Sterling White Lead Co., New Kensington, Pa.	May, 1894.
BIGELOW, E. M.,	Director of Department of Public Works, Pittsburg, Pa.	Jan., 1880.
BLACK, SAMUEL W.,	Real Estate Agent, S. W. Black & Co., 318 Fourth Ave., Pittsburg, Pa.	March, 1891.
BODEN, DANIEL,	Supt. Mansfield Coal and Coke Co., Carnegie, Pa.	March, 1895.
BOLE, WM. A.,	Supt. Westinghouse Machine Co., East Pittsburg, Pa., 5512 Howe St., Pittsburg, Pa.	March, 1884.
BOWMAN, A. M.,	Mahan P. O., Beaver County, Pa.	Oct., 1895.
BOWMAN, F. M.,	Engineer, Structural Iron Works, Riter & Conley, Allegheny, Pa.	April, 1893.
BRADFORD, WILLIAM,	Civil Engineer, 142 S. Negley Ave., Pittsburg, Pa.	March, 1893.
BRAKES, JAMES,	Chemist for Chateaugay Ore & Iron Co., Lyon Mountain, Clinton Co., New York.	April, 1892.
BRANNE, J. S.,	Koken Iron Works, St. Louis, Mo.	Feb., 1892.
Brashear, John A.,	Astronomical and Physical Instrument Manufacturer, 260 Perryville Ave., Allegheny, Pa.	March, 1884.
BROWN, ALBA FISK,	271 40th St., Pittsburg, Pa.	April, 1893.

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Name.	Occupation and Address.	Date of Election.
BROWN, W. R.,	Civil Engineer. City Hall, Pittsburg, Pa.	Jan., 1880.
Broune, Geo. H.,	General Manager Philadelphia Co., Second Floor, Westinghouse Building, Pittsburg, Pa.	Jan., 1880-
BRYAN, CHARLES W.,	Chief Engineer Edge Moor Bridge Works, Edge Moor, Delaware.	March, 1894.
BRYNN, PIERRE,	Shiffler Bridge Co., Pittsburg, Pa.	March, 1892.
BUENTE, C. F.,	Stone Contractor, Perryville Ave. and Charles St., Allegheny, Pa.	Jan., 1887.
CADMAN, A. W.,	Pres. Cadman, Mnfg. Co., 63 Water St., Pittsburg, Pa.	Jan. 1886.
CAMP, J. M.,	Metallurgical Engineer and Chemist for Duquesne Steel Works, and Blast Furnaces of Carnegie Steel Co., Ltd., Duquesne, Pa.	May, 1882.
CARD, W. W.,	Sec'y Westinghouse Air Brake Co., P. O. Box 273, Pittsburg, Pa.	June, 1892.
CARHART, DANIEL,	Dean and Professor of Civil Engineering at W. U. of P., Allegheny, Pa., 1410 Centre St., Station "D," Pittsburg, Pa.	Feb., 1883.
CARLIN, T. H.,	Manufacturer, 181 Robinson St. Allegheny, Pa.	May, 1885.
CARNEGIE, ANDREW,	5 West 51st St., New York.	April, 1880
CHAMBERS, JR., J. S.,	Civil Engineer. 19 Church Ave., Allegheny, Pa.	Sept., 1883.
CHESS, H. B.,	531 Wood St., Pittsburg, Pa.	Feb., 1880.
CHESTER, J. N.,	Pittsburg Sales Manager for Henry R. Worthington Co., 317 Third Ave., Pittsburg, Pa.	Dec., 1896.
CLAPP, G. H.,	Chairman Pittsburg Testing Laboratory, Limited, 325 Water St., Pittsburg, Pa.	Nov., 1882.
CLIFTON, W. R.,	Chemist, Shenango Valley Steel Co., Chemist, Raney & Berger Iron Co., New Castle, Pa. 65 Penn Ave., New Castle, Pa.	April, 1892.
COFFIN, W. C.,	N. Y. Mgr. for Reiter & Conley, 39 Cortlandt St., New York.	Oct., 1883.
CONNELLEY, C. B.,	Principal Manual Training School of Allegheny, Pa., Page and Fulton Sts., 5th Ward School, Allegheny, Pa.	May, 1891.
CONNER, W. A.,	Gen. Supt. Standard Underground Cable Co., Pittsburg, Pa., 10 Oakland Square, Pittsburg, Pa.	March, 1897.
COOPER, C. A.,	Civil Engineer, 410 Grant Street, Pittsburg, Pa.	Feb., 1881.

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
COOPER, FRANK IRVING,	Architect, Wayland, Mass.	April, 1892.
COREY, W. E.,	Genl. Supt. Homestead Steel Works of Carnegie Steel Co., Ltd., Munhall, Pa.	Nov., 1897.
CORNELIUS, W. A.,	Supt. of 33-in., 23-in. and 10-in Structural Mills, Homestead Steel Works, of Carnegie Steel Co., Ltd., Munhall, Pa.	Nov., 1889.
COSTER, W. H.,	Chemist, 4502 Fifth Ave., Pittsburgh, Pa.	April, 1892.
COVELL, VERNON R.,	Civil Engineer with County Engineer of Allegheny Co., Pittsburgh, Pa. 440 Rebecca Ave., Wilkinsburg, Pa.	Nov., 1897.
CROOKER, JR., RALPH,	Mechanical Engineer, with Jones & Laughlins, Ltd., S. S., Pittsburgh, Pa.	March, 1896.
CUNNINGHAM, E. W.,	Civil Engineer, 1637 Indiana Ave., Chicago, Ill.	March, 1896.
CUNNINGHAM, JNO. M.,	Civil Engineer and Contractor, Southern Agent for Schultz Bridge & Iron Co., Ltd., 620 Hennen Building, New Orleans, La.	Dec., 1896.
CURRY, H. M.,	Mgr. Carnegie Steel Co., Carnegie Building, Pittsburgh, Pa.	Sept., 1880.
DAFT, L. J.,	Constructing Engineer, with Ingersoll, Sergeant Drill Co., Cleveland, Ohio., 658 East Prospect St., Cleveland, Ohio.	Sept., 1897.
DAVIS, A. V.,	Ast. Mgr. Pittsburg Reduction Co., 325 Water St., Pittsburgh, Pa.	April, 1892.
<i>Davis, Charles,</i>	County Engineer, Court House, Pittsburgh, Pa.	Jan., 1880.
DAVISON, G. S.,	Civil Engineer, Wilkins & Davison, Rm. 91 Westinghouse Building, Pittsburgh, Pa.	Dec., 1880.
DEFORTH, J. M.,	Civil Engineer, Pittsburg Bridge Co., 38th St. and A. V. R., Pittsburgh, Pa.	Feb., 1891.
<i>Dempster, Alex.,</i>	Pres. Pittsburg Wire Co., 232 Fifth Ave., Pittsburgh, Pa.	Jan., 1880.
DIESCHER, SAMUEL,	Civil and Mechanical Engineer, Rm. 714 Hamilton Building, Pittsburgh, Pa.	Jan., 1880.
DINKEY, ALVA C.,	Supt. Electrical Dept. Homestead Steel Works, of Carnegie Steel Co., Ltd., Munhall, Pa.	Nov., 1897.
DOXRUD, PETER,	Contracting Engineer. R. S. Wright & Co., P. O. Box 832, Pittsburgh, Pa.	Nov., 1890.
DRATO, EDWARD T.,	Member of firm of C. G. Hussey & Co., 12 Sherman Ave., Allegheny, Pa.	Oct., 1890.

8 ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

Name.	Occupation and Address.	Date of Election.
DRIVER, C. M.,	Contractor. P. O. Box 541, Pittsburg, Pa.	Jan., 1892.
DUBBS, J. A.,	The Mexican Sulphur Co., 1942 Forbes St., Pittsburg, Pa.	Dec., 1892.
DUCKHAM, A. E.,	Civil Engineer, 232 Rebecca St., E. E., Pittsburg, Pa.	March, 1892.
DUDLEY, C. B.,	Chemist, P. R. R. Co., Altoona, Pa., (Drawer 334.)	April, 1892.
ECKERT, E. W.,	452 W. 153d St., New York.	Jan., 1881.
EDEBURN, W. A.,	Civil Engineer, Edeburn & Cooper, 410 Grant St., Pittsburg, Pa.	Jan., 1880.
EHLERS, C. W.,	Asst. Engineer, Bureau of Engineering and Surveys, City of Allegheny, Pa., 163 Lowrie St., Allegheny, Pa.	March, 1896.
ELLIOTT, J. R.,	Civil Engineer, with Wilkins & Davison, Rm. 91 Westinghouse Building, Pittsburg, Pa.	March, 1896.
ENGEL, G. U.,	Assist. Engineer, P., C., C. & St. L. Ry., General Offices Penna. Company, 10th St. & Penn Ave., Pittsburg, Pa.	Feb., 1888.
ENGSTRÖM, FRANS,	Asst. Engineer, Dept. Public Works, Pittsburg, Pa. Highland Park, Pittsburg, Pa., 3721 Bouquet St., Pittsburg, Pa.	Sept., 1882.
ERICKSON, EDWARD E.,	Engineer and Contractor, Conestoga Bldg., Pittsburg, Pa.	April, 1898.
ESTRADA, E. D.,	Mechanical Engineer, Rm. 701 Lewis Block, Pittsburg, Pa.	Feb., 1888.
ETCHES, HARRY,	Draughtsman, Duquesne Blast Furnaces of Carnegie Steel Co., Ltd., Duquesne, Pa., Evans Ave., McKeesport, Pa.	May, 1896.
EVANS, RAWDON,	Purchasing Agent, P. & L. E. R. R. Co., Rm. 804 Bank of Commerce Building, Pittsburg, Pa.	March, 1893.
FARRAR, C. J.,	Engineer and Contractor, Bennett & Farrar, Rm. 509 Penn Building, 708 Penn Ave., Pittsburg, Pa.,	Feb., 1892.
FAWCUS, THOS.,	Supt. of R. D. Nuttall Co., Allegheny, Pa.	Jan., 1896.
FERRARA, PETER,	Engineer with Wisconsin Bridge Co., 228 Tenth St., Milwaukee, Wis.	Feb. 16, 1897.
FESSENDEN, REGINALD A.,	Prof. of Electrical Engineering, Western University of Pa., Allegheny, Pa. Consulting Electrical Engineer, (Fessenden & Ridinger.) 410 Penn Ave., Pittsburg, Pa.	June, 1894.
FISHER, H. W.,	Electrical Engineer for Standard Underground Cable Co., 16th and Pike Sts., Pittsburg, Pa.	Jan., 1895.

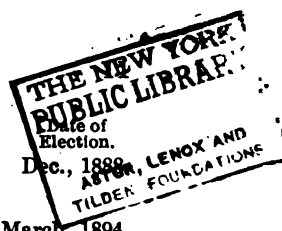
LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
FITZGERALD, CHARLES,	Supt. Consolidated Traction Co., 316 Evaline St., Pittsburg, Pa.	Jan., 1896.
FLACK, C. A.,	Civil Engineer with Ritter-Conley Co., Pittsburg, Pa., 1106 Hay St., Station "D," Pittsburg, Pa.	May, 1894.
FLANAGAN, G. E.,	Chief Draughtsman. Hydraulic Machine Co., 54th St., Pittsburg, Pa., 143 Home St., Pittsburg, Pa.	June, 1894.
FLINT, WM. P.,	Mechanical Engineer with Westinghouse Machine Co., East Pittsburg, Pa., P. O. Box 224, East Pittsburg, Pa.	April, 1898.
FOHL, W. E.,	Mining Engineer with J. H. Somers Fuel Co., Belle Vernon, Pa.	Jan., 1897.
FRANK, I. W.,	Pres. and Gen. Mgr. Frank-Kneeland Machine Co., 54th St. and A. V. R. R., Pittsburg, Pa.	Feb., 1882.
FRIEDLAENDER, EUGENE,	Electrical Engineer, with Carnegie Steel Co., Ltd., Duquesne Steel Works and Blast Furnaces, Duquesne, Pa.	April, 1897.
FROHMAN, E. D.,	Chemist for O. Hommet & Co., 23d St. and Penn Ave., Pittsburg, Pa.	April, 1896.
FROST, A. E.,	Prof. of Physics, Western University of Penna., Allegheny, Pa.	Jan., 1890.
FULTON, L. B.,	Pres. Chaplin-Fulton Mfg. Co., Bell Brass Founders and Machinists, 531 Wood St., Pittsburg, Pa.	April, 1888.
GARRIGUES, W. E.,	Consulting Chemical Engineer, Manager Duquesne Chemical Laboratory, 602 Times Bldg., Pittsburg, Pa.	May, 1895.
GILLESPIE, T. A.,	Pres. the T. A. Gillespie Co., Westinghouse Building, Pittsburg, Pa.	March, 1897.
GLAFKY, F. A.,	Engineer of Bridges, Carnegie Steel Co., Ltd., Keystone Bridge Works, 51st St., Pittsburg, Pa.	Oct., 1883.
GLASS, G. G.,	Chemist, La Belle Steel Works, Allegheny, Pa.	March, 1892.
GOLDIE, WILLIAM,	Mechanical Expert, with Dilworth, Porter & Co., P. O. Box 575, Wilkinsburg, Pa.	Nov., 1894.
GOODYEAR, S. W.,	With Crescent Steel Co., Waterbury, Conn.	Feb., 1890.
GOW, A. M.,	No. 947 Penn Ave., Pittsburg, Pa.	Jan., 1893.
GRANT, H. E.,	Chairman of Oliver P. Scaife & Co., Ltd., Chatsworth Ave., Hazelwood, Pa.	June, 1883.

Name.	Occupation and Address	Date of Election.
GREENWOOD, G. F.,	Chief Engineer and General Manager Consolidated Traction Co., Pittsburg, Pa., Times Building, Pittsburg, Pa.	Oct., 1892.
GROSS, ABRAHAM,	Student, Western University of Penna., Allegheny, Pa., 23 Allegheny Ave., Allegheny, Pa.	Feb., 1898.
GWINNER, JR., FRED,	General Contractor, 19 Market St., Allegheny, Pa.	Sept., 1882.
HACKETT, G. W.,	National Cement Co., 1009 Liberty Ave., Pittsburg, Pa.	March, 1883.
HALLGREN, EMIL,	Mechanical Engineer, With Mackintosh, Hemphill & Co., Ltd., Pittsburg, Pa.	Feb., 1891.
HANDY, J. O.,	Chief Chemist, Pittsburg Testing Laboratory, Ltd., 325 Water St., Pittsburg, Pa.	Nov., 1896.
HARDIE, J. B.,	Engineer, with Carnegie Steel Co., Ltd., Keystone Bridge Works, Pittsburg, Pa.	Feb., 1891.
HARLOW, G. R.,	Civil Engineer, Station "D," Pittsburg, Pa.	April, 1881.
HARLOW, JAS. H.,	Jas. H. Harlow & Co., Hydraulic Engineers, Station "D," Pittsburg, Pa.	Jan., 1880.
HARRISON, A. B.,	Chemist, Clinton Iron and Steel Co., 7 LaBelle St., S. S., Pittsburg, Pa.	March, 1892.
HAYS, J. A.,	147 South 18th St., Pittsburg, Pa.	Feb., 1893.
HAYS, W. H.,	Chairman Iron City Tool Works, 3rd and Smallman Sts., Pittsburg, Pa.	Oct., 1892.
HEMPHILL, JAMES,	President Mackintosh, Hemphill & Co., Foot 12th St., Pittsburg, Pa.	Jan., 1880.
HENRY, W. D.,	Sec'y Pittsburg Terra Cotta Lumber Co., Rm 816 Carnegie Building, Pittsburg, Pa.	April, 1893.
HERRING, E. A.,	Civil Engineer, 272 Flak St., Pittsburg, Pa.	April, 1896.
HIRSH, RICHARD,	Draughtsman, with H. K. Porter & Co., 49th St., 1318 Fifth Ave., Pittsburg, Pa.	Dec., 1894.
HOAG, JR., I. V.,	U. S. Asst. Eng., Federal Building, Pittsburg, Pa. 170 South Ave., Allegheny, Pa.	Nov., 1888.
HODGKINSON, FRANCIS,	Engineer, with Westinghouse Machine Co., East Pittsburg, Pa., 5812 Howe St., East End, Pittsburg, Pa.	April, 1897.
HOHL, L. J.,	Civil Engineer, with Wilkins & Davison, 100 Boggs Ave., Duquesne Heights, Pittsburg, Pa.	Sept., 1888.

LIST OF MEMBERS.



Name.	Occupation and Address.	
HOLLAND, W. J.,	Chancellor Western University of Pennsylvania, Fifth Ave., Oakland, Pittsburg, Pa.	Dec., 1889.
HOLMES, A. G.,	Sec. Pittsburg Meter Co., East Pittsburg, Pa.	March, 1894.
HOUSE, F. E.,	Gen'l Supt. P. B. & L. E. R. R. Co., Carnegie Bldg , Pittsburg, Pa., Beaver, Pa.	March, 1892.
HUBER, S. V.,	Chief Engineer, with The Lloyd Booth Co., 263 Madison Ave., Youngstown, Ohio.	Dec., 1895.
HUNKER, WILLIAM J.,	Supt. Allegheny County Light Co., Thirteenth St., Pittsburg, Pa.	April, 1898.
Hunt, A. E.,	Pres. and Gen. Mgr. Pittsburg Reduction Co, Pres. Hunt Air Brake Co. Treas. and Vice Chairman Pittsburg Testing Lab., Ltd. Pres Georgia Bauxite and Mining Co., Room 701 Ferguson Bld., Pittsburg, Pa.	Oct., 1881.
HUSSEY, C. G.,	Curran & Hussey, Engineers and General Contractors, 307 Hussey Bldg., Pittsburg, Pa.	June, 1893.
HYDE, CHAS.,	Consulting Mechanical Engineer, Room 902 Lewis Block, Pittsburg, Pa.	Oct., 1887.
ISAACS, ABE S.,	Chemist, 140 Sheffield St., Allegheny, Pa.	Nov., 1897.
JAMISON, W. W.,	Supt. The Penn Mining Co. Seattle, Washington.	Sept., 1893.
JENKINS, J. B.,	Civil Engineer, Topographical Draughtsman Dept. of Street Improvements, 23d and Warden, New York City. 134 W. 127th St., New York City.	Dec , 1888.
JOHNSON, C. M.,	Analytical Chemist, with Park Bros. & Co., Box 101, Avaton, Pa.	April, 1892.
Johnson, T. H.,	Chief Engineer P., C. & St. L. Ry., 10th St. and Penn Ave., Pittsburg, Pa.	Jan., 1888.
JOHNSON, E. S.,	Chemist, Director of Laboratory of the Black Diamond Steel Co., Pittsburg, Pa., care Park, Brother & Co., Pittsburg.	April, 1895.
JONES, B. F.,	Jones & Laughlins, Ltd., South Side, Pittsburg, Pa.	April, 1881.
JONES, W. L.,	Jones & Laughlins, Ltd., South Side, Pittsburg, Pa.	March, 1888.
KARCH, JOSEPH P.,	Draughtsman, with Westinghouse Machine Co., East Pittsburg, Pa. Amber Club, Pittsburg, Pa.	April, 1898.
KAUFMAN, GUSTAVE,	Consulting Engineer and Contractor, Eighth Floor, 812 Hamilton Building, Pittsburg, Pa.	Nov., 1880.

12 ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

Name.	Occupation and Address.	Date of Election
KAY, JAS. I.,	Kay & Totten. Attorney at Law and Patent Solicitor, 426 Diamond St., Pittsburg, Pa.	Feb., 1885.
KELLER, CHAS.,	Chemist, 113 Biddle Ave., Station "D," Pittsburg, Pa.	March, 1895.
KELLER, E. E.,	Vice-President and General Manager Westinghouse Machine Co., East Pittsburg, Pa. Edgewood Park, Pa.	April, 1895.
KELLY, J. A.,	28th and Smallman Sts., Pittsburg, Pa.	March, 1885.
KELLY, M. B.,	Salesman and Auditor, Zug & Co., Ltd., 7 Wylie Ave., Pittsburg, Pa.	Oct., 1891.
KELLY, J. W.,	Contractor. Box 44, New Brighton, Pa.	Jan., 1885.
KEMERY, PHILO,	Chemist, Crescent Steel Works, 51st St. and A. C. R. R., Pittsburg. 227 Fisk St., Pittsburg, Pa.	April, 1892.
KEMLER, W. H.,	1823 Carson St., Pittsburg, Pa.	Feb., 1891.
KENNEDY, JULIAN,	Mechanical Engineer, Rm. 78 Vandergrift Building, Pittsburg, Pa.	May, 1886.
KIMBALL, F. I.,	Civil Engineer, Supt. Ocean Coal Co., Hermine, Pa.	June, 1888.
KING, T. M.,	B. & O. R. R., Baltimore, Md.	Feb., 1882.
KIRK, ARTHUR,	Arthur Kirk & Son, 910 Duquesne Way, Pittsburg, Pa.	March, 1882.
KIRTLAND, A. P.,	Sec. Marble Hill Quarry Co., Rm. 1206 Carnegie Building, Pittsburg, Pa.	Nov., 1887.
KLINGELHOFFER, G. E.,	Supt. Atwood & McCaffrey, Pittsburg, Pa., 5515 Howe St., E. E., Pittsburg, Pa.	Dec., 1895.
KOCH, W. E.,	Supt. of the Spang Steel and Iron Co., Sharpsburg, Pa.	April, 1887.
LAMB, GEO.,	Government Printing Office, Washington, D. C.	Feb., 1892.
LANGE, P. A.,	Supt. W. E. & Mfg. Co., East Pittsburg, Pa.	Oct., 1896.
LANGENHEIM, G. C.,	Civil Engineer, Supt. Bureau of Engineering and Survey, City Engineer's Office, Allegheny, Pa.	Feb., 1896.
LASH, H. W.,	Manager Carbon Steel Co., Pittsburg, Pa.	Oct., 1892.

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
LAUDER, GEO.,	Carnegie Steel Co., Rm. 325 Carnegie Building, Pittsburg, Pa.	May, 1885.
LAUGHLIN, ALEX.,	Furnace Contractor and Engineer, Mechanical Engineer of Alex. Laughlin & Co., Rm. 706 Lewis Block, Pittsburg, Pa.	Feb., 1893.
LE PONTOIS, LEON,	Electrical Engineer, 608 Lincoln Ave., E. E., Pittsburg, Pa.	Oct., 1893.
LEWIS, HARRY J.,	Civil Engineer, Times Building, Pittsburg, Pa.	May, 1890.
LEWIS, J. L.,	President of the Lewis Foundry and Machine Co., Ltd., 10th St., South Side, Pittsburg, Pa.	March, 1880.
LIGGETT, D. S.,	Real Estate Agent, Liggett & Goehring, Fourth Ave., Pittsburg, Pa.	Feb., 1892.
LOEFFLER, G. O.,	Chemist of Carbon Steel Co., Pittsburg, 153 Pearl St., Pittsburg, Pa.	April, 1892.
LOOMIS, DE WAYNE,	Crafton, Pa.	March, 1894.
LYNCH, TILLMAN D.,	Asst. Inspector, U. S. Navy, Munhall, Pa.	Feb., 1898.
LYNNE, MISS MARY L.,	Chemist to American Reduction Co., 1514-1526 Second Ave., 4621 Forbes St., Pittsburg, Pa.	March, 1893.
LYONS, J. K.,	Engineer in charge Bridge Detailing, Keystone Bridge Works, Carnegie Steel Co., Ltd., 214 Mathilda St., Pittsburg, Pa.	March, 1892.
MACBETH G. A.,	Pres. Geo. A. Macbeth Co., Rm. 311 Telephone Building, Pittsburg, 717 Amberson Ave., Pittsburg, Pa.	Jan., 1880.
MACK, J. S.,	Mining Engineer for Coulter & Huff and Carbor & Hempfield Coal Companies, Greensburg, Pa.	April, 1897.
MACKENZIE, JAS.,	Carnegie Steel Co., Ltd., 406 Carnegie Building, Pittsburg, Pa.	Nov., 1892.
MANNING, W. T.,	Chief Engineer, B. & O. R. R., B. & O. R. R., Baltimore, Maryland.	March, 1892.
MARDEN, W. R.,	Engineer, The Pittsburg Bridge Co., 38th St. and A. V. R. R., Pittsburg, 5167 Penn Ave., Pittsburg, Pa.	May, 1896.
MARSHALL, C. D.,	Secy. and Engineer Shiffler Bridge Co., 141 Fairmount Ave., E. E., Pittsburg, Pa.	May, 1896.
MARSHALL, G. D.,	Asst. Inspector of Steel, U. S. N., Steelton, Pa.	Jan., 1897.

14 ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

Name.	Occupation and Address.	Date of Election.
MARTIN, WILLIAM,	U. S. Asst. Engineer, P. O. Box, 670 Pittsburg, Pa.	Jan., 1880.
MATHISEN, CHRISTEN,	Engineer, Raadhusgaden 26 III, Christiana, Norway.	Jan., 1896.
MEAD, EDWD.		Dec., 1883.
MENOUGH, H. S.,	5180 Cypress St., Pittsburg, Pa.	Dec., 1892.
MERCADER, CAMILLE,	Andrasig Strasse 23, Budapest, Hungary.	Sept., 1890.
MESTA, GEORGE,	Pres. Leechburg Foundry and Machine Co., Rm. 708 Lewis Block, Pittsburg, Pa.	March, 1888.
<i>Metcalf, William,</i>	Consulting Engineer, 208 Ferguson Block, Pittsburg, Pa.	Jan., 1880.
MEYRAN, L. A.,	Sec. and Treas., Canonsburg Iron & Steel Co., Rm. 406 Germania Savings Bank Building, Pittsburg, P. O. Box 954, Pittsburg, Pa.	Jan., 1884.
MILLER, H. B.,	281-66th Place, Woodlawn, Chicago, Ill.	March, 1893.
MILLER, HENRY F.,	Mechanical Engineer, with National Tube Works Co., McKeesport, Pa.	Jan., 1898.
MILLER, WILSON,	Pres. Pittsburg Locomotive and Car Works, 18 Lincoln Ave., Allegheny, Pa.	May, 1885.
MILLIKEN, A. C.,	Pottsville Iron and Steel Co., Pottsville, Pa.	Oct., 1880.
MOHR, JACOB A.,	Chemist, with Carnegie Steel Co., Ltd., Duquesne Steel Works, Duquesne, Pa.	Jan., 1897.
MOORE, JAS. R.,	Sec'y and Treas. Moorehead Bro. & Co., Inc., Sharpsburg, Pa.	May, 1897.
MOORHEAD, DAVID L.,	Civil Engineer and Surveyor, Indiana, Pa.	Jan., 1898.
MORGAN, THOMAS R.,	Late Gen'l Mgr. Morgan Engineering Co., 402 Atlantic Ave., East End, Pittsburg, Pa.	March, 1898.
MORRIS, G. W.,	General Manager of A. French Spring Co., P. O. Box 656, Pittsburg, Pa.	Oct., 1886.
MORRISON, THOS.,	Gen. Supt. Edgar Thompson Steel Works and Furnaces, The Carnegie Steel Co., Ltd., Braddock, Pa.	April, 1893.
MOREE, E. K.,	Civil Engineer, Rm. 1206 Carnegie Building, Pittsburg, Pa.	Jan., 1896.
MUELLER, GUSTAVE,	Chemist, with Pittsburg Testing Laboratory 325 Water St., Pittsburg, 278 Howard St., Allegheny, Pa.	March, 1890

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
MONROE, ROBT.,	R. Monroe & Sons, Boiler Manufacturers, 23d and Smallman Sts., Pittsburg, Pa.	April, 1880.
MCCLELLAND, E. S.,	Chief Draughtsman Westinghouse Machine Co., East Pittsburg, Pa., Baxter St., near Brushton Ave., Pittsburg, Pa.	April, 1895.
MCCCLINTIC, HOWARD H.,	Asst. Gen. Mgr. Shiffler Bridge Co., 48th St. and A. V. R. R., Pittsburg, Pa.	Oct., 1892.
MCCCLINTOCK, H. P.,	Manufacturer, McClintock & Irvine, South Ave. and Snowden St., Allegheny, Pa	Jan., 1891.
MCCONNELL, J. A.,	203 Water St., Pittsburg, Pa.	May, 1885.
MCCRICKART, J. MONT.,	Mining Engineer with Selwyn M. Taylor, 420 Bissell Block, Pittsburg, Pa.	Jan., 1898.
MCDONALD, F. A.,	Civil and Mining Engineer, Rm. 81. Penn Building, Pittsburg, Pa.	March, 1895.
MCDONALD, THOS. M.,	General Supt. The Ohio Steel Co., Youngstown, Ohio. 307 Madison Ave., Youngstown, Ohio.	March, 1893.
MCDONOUGH, JOHN,	Master Mechanic, Duquesne Steel Works, of Carnegie Steel Co., Ltd., Duquesne, Pa.	March, 1898.
MCGARY, DANIEL.	Master Mechanic for J. Painter & Sons' Co., S. S., Pittsburg, 20 Meriden St., Duquesne Heights, Pittsburg, Pa.	March, 1892.
MCGARY, E. L.,	Chief Draughtsman for Frank-Kneeland Machine Co., Pittsburg Pa., 20 Meriden St., Duquesne Heights, Pittsburg, Pa.	May, 1897.
McKAIG, T. B.,	Sec'y Trade Dollar Mining and Milling Co., Rm. 822 Carnegie Building, Pittsburg, Pa.	Jan., 1891.
MCKELVY, J. P.,	Chemist, with Mackintosh, Hemphill & Co., Pittsburg, Pa.	March, 1892.
MCKENNA, A. G.,	Chemist, Firth-Sterling Steel Co., Demmler, Pa.	April, 1892.
MCKINLEY, ROBERT M.,	Signal Engineer, with Penna. Lines West of Pittsburg. 377 Main St., Pittsburg, Pa.	April, 1898.
McLEOD, JOHN,	Engineer of Tests, Carnegie Steel Co., Ltd., Carnegie Building, Pittsburg, Pa.	March, 1897.
McMURTRY, G. G.,	Pres. Apollo Iron & Steel Co., Care Wallace P. Bache, P. O. Box 1427, Pittsburg, Pa.	Feb., 1882.
McNAUGHER, DAVID W.,	Civil Engineer, Inspection and Tests, Halsted & McNangher, 1417 Park Building, Pittsburg, Pa.	Dec., 1896.
McQUISTON, JAMES,	Jas. McQuiston & Co., 26th and Railroad Sts., Pittsburg, Pa.	Feb., 1885.

Name.	Occupation and Address.	Date of Election.
NAEGLEY, JOHN,	Architect and Engineer, Rm. 718 Hamilton Building, Pittsburg, Pa.	Jan., 1880.
NEELAND, M. A.,	Mechanical Engineer, with The Ohio Steel Co., Youngstown, Ohio.	May, 1894.
NICHOLS, C. H.,	Civil Engineer, with Post & McCord, 289 4th Ave., New York.	Nov., 1891.
NICHOLS, COL. T. B.,	Retired Officer of U. S. Army, 8 Oak St., Plattsburg, N. Y.	Jan., 1880.
NIMICK, F. B.,	Singer, Nimick & Co., Inc., South Side, Pittsburg, Pa.	April, 1880.
NOBLE, PATRICK,	Gen. Mgr The Pacific Rolling Mill Co., San Francisco, Cal., 100 Market St., San Francisco, Cal.	Feb., 1882.
NURICK, ALEXANDER,	Chief Draughtsman of Structural Department, Jones & Laughlins, Ltd., South Side, Pittsburg, Pa.	Nov., 1892.
OPSION, O. C.,	Chief Draughtsman of Shiffler Bridge Co., Pittsburg, Pa.	March, 1892.
PAGE, GEORGE S.,	Supt. P. B. & Co., Ltd., Care Park Brother & Co., Ltd., Pittsburg, Pa.	Nov., 1892.
PANCOAST, ALBERT,	Chief of Bureau of Inspection of Schoen Pressed Steel Co., Woods Run, Allegheny, Pa.	March, 1897.
PAINTER, PARK,	J. Painter & Sons Co., Pittsburg, Pa. 245 Ridge Ave., Allegheny, Pa.	March, 1884.
PALMER, W. P.,	Second Vice-Pres. Illinois Steel Co. The Rookery, Chicago, Ill.	Nov., 1888.
PARKIN, CHAS.,	With Crescent Steel Co., New Kensington, Pa.	Jan., 1880.
PARSONS, BURT H.,	Engineer. New York Office, Jones & Laughlins, Ltd., Pittsburg, Pa. 257 Broadway, New York City.	Dec., 1891.
PATTERSON, F. W.,	Civil Engineer. Rm. 29, Court House, Pittsburg, Pa.	May, 1894.
PATTERSON, PETER,	Supt. National Tube Works, McKeesport, Pa.	Feb., 1881.
PATTERSON, P. C.,	Consulting Engineer, National Tube works. McKeesport Pa. 529 Versailles Ave., McKeesport, Pa.	March, 1892.
PECK, G. L.,	Supt. Pittsburg Division P. C. C. and St. L. Ry., Rm. 10 Union Station, P. R. R., Pittsburg, Pa.	Oct., 1896.
PHILLIPS, F. C.,	Prof. Chemistry, Western University of Penn'a. Allegheny, Pa.	Jan., 1880.

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
PHILLIPS, JNO. M.,	Manufacturer, Manager of Phillips Mine Supply Co., South 23d and Mary Sts., Pittsburg, Pa.	March, 1898.
PIERCE, C. I.,	Western Tube Co. Kewanee, Ill.	March, 1892.
PORTER, J. C.,	Secretary and Treasurer. Care Sprang Steel and Iron Co., Sharpsburg, Pa.	Dec., 1881.
PORTER, J. E.,	Sec. and Treas. Carroll-Porter Boiler and Tank Co., 201 Penn Ave., Pittsburg, Pa.	May, 1887.
PRENTICE, W. J.,	Mngr. National Cement Co., Ltd., Pres. Pittsburg Mineral Screen Co., Director Royal Tennessee Marble Co., 1009 Liberty St., Pittsburg, Pa.	Jan., 1893.
PURVES, JAS.,	P. O. Box 375, Sharpsburg, Pa.	Dec., 1888.
RAINEY, CHARLES T.,	Mining Engineer and Map Publisher, 700 Ninth St., Washington, D. C.	Jan., 1898.
REED, HUGH A.,	Member of firm of U. Baird Machinery Co. 123 125 Water St., Pittsburg, 167 Robinson St., Allegheny, Pa.	June, 1893.
REES, T. M.,	Vice-Pres. and Gen. Mgr. J. Rees & Sons, P. O. Box 709, Pittsburg, Pa.	Jan., 1880.
RENO, G. E.,	Reno & Johns, Insurance Agents, 306 Fourth Ave., Pittsburg, Pa.	May, 1883.
RHODES, JOSHUA,	Penn'a Tube Works, Pittsburg, Pa.	Jan., 1880.
RICKETSON, J. H.,	A. Garrison Foundry Co., 10 Wood St., Pittsburg, Pa.	Jan., 1880.
RIDDLE, WALTHER,	Chemist, 287 Ridge Ave., Allegheny, Pa.	Jan., 1892.
RIDINGER, CHARLES W.,	Electrical Engineer, (Fessenden & Ridinger, 410 Penn Ave., Pittsburg, Pa.) 69 Wilson Ave., Allegheny, Pa.	Oct., 1896.
RIGHTS, LEWIS D.,	Berlin Iron Bridge Co., East Berlin, Conn.	March, 1898.
ROBBINS, F. L.,	Coal Operator, Pres. Pittsburg, Fairport & Northwestern Dock Co., Pres. Robbins Coal Mining Co., etc., 232 Fifth Ave., Pittsburg, Pa.	Jan., 1888.
Roberts, T. P.,	Engineer. 361 Craig St., Pittsburg, Pa.	Jan., 1880.
RODD, THOS.,	Chief Engineer Penn'a Co., Tenth and Penn Ave., Pittsburg, Pa.	Jan., 1880.
ROGERS, CHARLES O.,	Hydraulic Engineer, with The Denning Co., Salem, Ohio.	April, 1897.

18 ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

Name.	Occupation and Address.	D E Nov
ROUSSEAU, H. H.,	Civil Engineer. 36th St. and A. V. R. R., Pittsburg, Pa.	Nov
ROWLAND, R. A.,	Manager Cement Dept. of Chas. E. Pope & Co., 421 Wood St., Pittsburg, Pa. 5534 Hay St., East End, Pittsburg, Pa.	March
RUHE, C. H. W.,	Book-Keeper, 1423 Bluff St., Pittsburg, Pa.	Nov.
RUTHERFORD, BRABAZON,	Electrical Engineer for Allegheny County Light Co., Pittsburg, Pa. 4 Highland Place, Pittsburg, Pa.	Nov.
RUUD, EDWIN,	Fuel Gas & Mfg. Co., East Pittsburg, Pa.	Jan.
SCAIFE, O. P.,	O. P. Scaife & Co., Ltd., 421 Wood St., Pittsburg, Pa.	April
<i>Scaife, W. Lucien,</i>	Chairman Scaife Foundry & Machine Co., 28th and Smallman Sts., Pittsburg, Pa.	March
SCAIFE, W. M.,	Scaife Foundry & Machine Co., 336 Ridge Ave., Allegheny, Pa.	Sept.
SCHADE, CHARLES G.,	Engineer, with Carnegie Steel Co., Ltd., 120 N. Evaline St., Pittsburg, Pa.	Sept.
SCHADE, GEORGE C.,	Chief Clerk Keystone Bridge Works, Dept. of Carnegie Steel Co., Ltd., Pittsburg, Pa. 296 Main St., Pittsburg, Pa.	March
SCHELLENBERG, F. Z.,	Consulting Engineer, 335 First Ave., Pittsburg, Pa.	Feb.,
SCHLUDERBERG, GEO. W.,	Coal Operator and Manager of Mines, Oak Ridge Coal Co., Ltd., First Pool, Monongahela Gas Coal Co., 374 Ridge Ave., Allegheny, Pa.	March,
SCHMID, ALBERT,	Westinghouse Electric & Manufacturing Co., East Pittsburg, Pa.	Feb.,
SCHOYER, A. M.,	Superintendent of Telegraph, Penn'a Lines West of Pittsburg, 43 Sherman Ave., Allegheny, Pa.	Feb.,
SCHULTZ, O. G.,	Secy. and Treas. of Schultz Bridge Iron Co., Box 65, McKees Rocks, Pa.	Nov.,
SCHWARTZ, F. H.,	Bureau of Engineers and Surveyors, Dept. of Public Works, Pittsburg, Pa. 247 Matilda St., Pittsburg, Pa.	Nov.,
SCOTT, CHARLES F.,	Electrical Engineer, Westinghouse Electric & Manufacturing Co., East Pittsburg, Pa.	April,
SCOTT, JAS.,	Supt. Lucy Furnaces, Carnegie Steel Co., Ltd., Pittsburg, Pa.	Feb.,
SEWALL, A. W.,	Secy. Mack Manufacturing Co., Secy. Penn'a Asphalt Paving Co., Rm. 1107, Nos 35 37 Nassau St., New York, N. Y.	June,

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
SHAW, A. G.,	Civil Engineer, County Engineer's Office, Pittsburg, Pa.	Jan., 1889.
SHAW, H. C.,	Secy. Lewis Foundry & Machine Co., S. S., Pittsburg, Pa. Glenshaw, Pa.	May, 1894.
SHAW, W. W.,	Civil Engineer, Sharpsburg, Pa.	Jan., 1889.
SHOOK, LEVI,	Shook-Anderson Manufacturing Co., First Ave. & Ferry St., Pittsburg, Pa.	May, 1883.
SINGER, G. H.,	Singer, Nimick & Co., Inc., 136 Water St., Pittsburg, Pa.	Sept., 1880.
SINGER, R. R.,	Rm. 56, 331 Fourth Ave., Pittsburg, Pa.	May, 1890.
SINGER, W. H.,	Pres. Singer, Nimick & Co., Singer, Nimick & Co., S. S., Pittsburg, Pa.	Sept., 1880.
SIVERTSEN, O.,	Chief Draughtsman of New Castle Engineering Works, New Castle, Pa.	March, 1892.
SKINNER, O. C.,	Chief Chemist, Schoenberger Steel Co., Pittsburg, Pa.	Dec., 1896.
SLOCUM, F. S.,	Chemist American Iron Works, Jones & Laughlins, Ltd., S. S., Pittsburg, Pa. Tenth Ave. and Amity St., Homestead, Pa.	April, 1892.
SMITH, F. S.,	Electrical Engineer, Robinson St., Allegheny, Pa.	Jan., 1890.
SNYDER, ANTES,	Engineer Rights of Way, P. R. R. Blairsville, Indiana Co., Pa.	Feb., 1880
SNYDER, C. H.,	Civil Engineer, with Milliken Bros., 39 Cortlandt St., New York.	Oct., 1892.
SNYDER, W. P.,	W. P. Snyder & Co., German National Building, Pittsburg, Pa.	April, 1884.
SPEER, J. R.,	Manager Blast Furnaces, Schoenberger & Co., Pittsburg, Pa.	Dec., 1894.
STAFFORD, C. E.,	Illinois Steel Co., Chicago, Ill.	May, 1881.
STAFFORD, S. G.,	Chemist, 516 Market St., Pittsburg, Pa.	April, 1893.
STAHL, K. F.,	Supt. James Irwin & Co., 57th St. and A. V. R. R., Pittsburg, Pa.	April, 1892.
STEVENSON, W. S.,	Oil and Gas Operator, Fairmont, West Virginia.	Jan., 1886.
STEWART, J. H.,	Iron Broker for Humphreys, Stewart & Co., Rm. 712 Lewis Block, Pittsburg, Pa.	Oct., 1886.

Name.	Occupation and Address.	D E C
STEWART, R. T.,	Prof. Mechanical Engineering, Western University of Pennsylvania. Allegheny, Pa.	Dec.
STILLWELL, L. B.,	Electrical Director of Niagara Falls Power Co., Cataract Construction Co., Niagara Falls Power Co., Niagara Falls, N. Y.	Jan.
STRUNZ, F. B.,	Manufacturing Chemist S. Strunz & Son, 708 Bingham St., Pittsburg, Pa.	Feb.
SUTTON, STANNBURY,	Secy. of the Consolidated Lamp and Glass Co., Coraopolis, Pa. 220 Western Ave., Allegheny, Pa.	Dec.
STUPAKOFF, S. H.,	Supt. of the Union Switch and Signal Co., Swissvale, Pa. 545 Turrett St., E. E., Pittsburg, Pa.	Feb.
SWAN, ROBERT,	Vice Pres. the T. A. Gillespie Co., 31 North Ave., Allegheny, Pa.	Feb.
Swenson, Emil,	Gen. Supt. Keystone Bridge Works, Carnegie Steel Co., Ltd., Pittsburg, Pa. 3511 Hays St., E. E., Pittsburg, Pa.	April,
TAILMAN, F. G.,	Mang'r. branch office of Brown Hoisting & Conveying Machine Co., 1112 Carnegie Building, Pittsburg, Pa.	Oct.,
TAYLOR, R. H.,	Civil Engineer, with Carnegie Steel Co., Ltd., Edgar Thomson Steel Works, Braddock, Pa.	Feb.,
Taylor, E. R.,	Gen. Supt. of Transportation Penna. Lines West of Pittsburgh. 1008 Penn. Ave., Pittsburg, Pa.	April.
TAYLOR SAM'L A.,	Civil and Machine Engineer Rms. 8208 Schenck Bldg., Pittsburg, Pa.	Jan..
TAYLOR, S. M.,	Civil and Machine Engineer Rms. 8208 Schenck Bldg., Pittsburg, Pa.	Jan..
TAYLOR, W. C.,	Consult. Mechanical and Electrical Engineer, Rm. 606 So. Warren St., Pittsburg, Pa.	Dec.
TAYLOR, W. E.,	Mfg. Pittsburg, Pa. (Spec. Steel) Western Pack Co., Rm. 606 1211 1/2 Ave., Pittsburg, Pa.	May.
THOMAS THOMAS H.,	Production Engineer, Engineers' Dept. of Westinghouse Electric & Mfg. Co., Erie, Pa. 400 E. 10th St., Pittsburg, Pa.	April.
THOMPSON, J. A.,	Architect Box 728, Pittsburg, Pa.	April.
THOMAS, J. S.,	Chemist and Engineer, Cons. Mfg. Steel Co. (Carnegie), 100 So. Warren St., Pittsburg, Pa.	April.
TINK, S. J.,	Civil Engineer, The Stearns & Smith Foundry Co., The Pittsburg and W. Va. Foundry Co., Manufacture of Cast Iron & Steel, Rm. 606 320 North Ave., Pittsburg, Pa.	March.

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
TONNELLE, THEO.,	Chemist, P. O. Box 222, McKeesport, Pa.	Dec., 1890.
TOWNSEND, C. W.,	Mechanical Engineer, Mgr. for Westinghouse, Church, Kerr & Co., Rm. 81, Westinghouse Building, Pittsburg, Pa.	March, 1892.
TRIMBLE, ROBT.,	Asst. Engineer Penna. Co., 10th St. and Penn Ave., Pittsburg, Pa.	Jan., 1880.
TURNER, C. A. P.,	Gillette-Herzog Mfg. Co., Minneapolis, Minn.	Sept., 1893.
UNGER, J. S.,	Supt. of Armor Dept. Carnegie Steel Co., Ltd., Munhall, Pa.	Feb., 1896.
URQUHART, G. C.,	Asst. Engr., Chief Engr. Dept., P. C., C. & St. L. Ry. Co., Rm. 609, Penna. Lines, 10th St. and Penn Ave., Pittsburg, Pa.	May, 1893.
VANDERSLICE, JOHN,	Shop Supt. Keystone Bridge Works Dept. Carnegie Steel Co., Ltd., 5434 Broad St., Pittsburg, Pa.	March, 1897.
VANDIVORT, THEO.,	Civil Engineer, Asst. Engineer, Engineer Rights of Way, P. R. R., Blairsville, Indiana Co., Pa.	Feb., 1892.
VERNER, M. S.,	Civil Engineer, Oakmont, Pa.	May, 1 85.
VIERHELLER, PH.,	25 Plymouth St., Duquesne Heights, Pittsburg, Pa.	Dec., 1892.
WAGNER, KARL VON	Civil Engineer, Bridge Building. McKees Rocks, Pa.	April, 1893.
WALKER, J. W.,	Pres. and Gen. Mgr. Shiffler Bridge Co., 240 44th St., Pittsburg, Pa.	Jan., 1880.
WALKER, R. L.,	Mechanical Engineer, No. 50 Library Place, Allegheny, Pa.	Dec., 1891.
WARDEN, C. F.,	Civil Engineer, 7 Shetland Ave., Pittsburg, Pa.	Jan., 1883.
WELDIN, LEWIS C.,	Civil Engineer, Asst. Engineer P. R. R., Rm. 7, Union Station, P. R. R., Pittsburg, Pa.	May, 1894.
WENDT, E. F.,	Asst. Engineer P. & L. E. R. R. Co., 717 Third Ave., New Brighton, Beaver Co., Pa.	April, 1892.
WHITE, F. L.,	Chief Draughtsman for Lucy Furnaces, Carnegie Steel Co., Ltd., 4616 Plummer St., Pittsburg, Pa.	May, 1892.
WHITE, T. S.,	Vice-Pres. and Chief Engineer of Penn Bridge Co., Beaver Falls, Pa.	May, 1883.
WHITNEY, PAUL S.,	Draughtsman Keystone Bridge Works, of Carnegie Steel Co., Ltd., Pittsburg, Pa., Ingram, Pa.	Nov., 1897.

DECEASED MEMBERS.

Name.	Elected.	Deceased.
ABBOTT, WM. C.,	Dec., 1890,	Oct. —, 1891.
ACHENHEIL, CHAS.,	Jan., 1880,	June 20, 1890.
AIKMAN, E. G.,	March, 1888,	June —, 1893.
AMSLER, CARL,	April, 1880,	— — — —
BECKER, M. J.,	Jan., 1880,	Aug. 23, 1896.
BECKFIELD, CHAS.,	Jan., 1885,	— — — —
BLANK, HUGO,	Sept., 1883,	March 18, 1893.
BLACK, F. C.,	March, 1882,	— — — —
BRIDGES, H. R.,	May, 1885,	— — — —
BRUCE, NIGEL,	March, 1884,	— — — —, 1886.
BRUCE, ROBT.,	Dec., 1883,	— — — —
CARLIN, DAVID,	— — —, 1880,	— — —, 1881.
CARLIN, THOS.,	Feb., 1882,	— — —, 1884.
CARNEGIE, T. M.,	April, 1880,	— — —, 1886.
CLARK, H. R.,	— — —, 1880,	— — — —
CLARK, R. N.,	Jan., 1888,	March 17, 1894.
CLARK, THOS. C.,	Jan., 1883,	— — — —
COULTER, J. A.,	— — —, 1880,	Nov. —, 1885.
CRAVATH, ROBT.,	— — —, 1880,	July 17, 1883.
CRAWFORD, E. S.,	Sept., 1883,	— — — —
DAGRON, JAS. G.,	Oct., 1883,	— — — —
DICKSON, C. G.,	April, 1881,	— — — —
DICKENSON, H. C.,	Feb., 1881,	Jan. —, 1889,
DUBOIS, JKO.,	April, 1884,	— — — —
DWIGHT, W. S.,	April, 1882,	Jan. 3, 1883.
EDWARDS, GEO. B.,	Jan., 1882,	— — — —
EUWER, A. H.,	Nov., 1887,	Jan. —, 1891.
FERRIN, G. W. G.,	March, 1886,	Nov. 22, 1896.
FRONHEISER, J. J.,	May, 1892,	March 16, 1894.
GOLDTHOYS, S. H.,	Feb., 1880,	— — —, 1890.
GOODWIN, JOHN M.,	Jan., 1890,	— — — —
GOTTLIEB, A.,	Jan., 1880,	Feb. 9, 1894.
HARTUPPE, A.,	Feb., 1880,	Sept. 16, 1891.
HERRON, FRED,	Nov., 1885,	April 5, 1896.
HICKS, GEO. J.,	Feb., 1891,	— — —, 1891.
HOHN, IGRATIM,	Jan., 1880,	— — — —
HUNNING, FRANK.	Jan., 1883,	— — — —
JONES, WM. R.,	Sept., 1880,	Sept. —, 1889.
KLOMAN, ANDREW,	Feb., 1880,	Dec. 19, 1880.
LOWRY, JOS. L.,	Jan., 1880,	— — — —
MILHOLLAND, J. B.,	Feb, 1882,	May 8, 1896.

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Name.	Elected.	Decd
MILLER, JAS.,	Jan., 1885,	_____
MILLER, WM.,	April, 1880,	Sept. 21
MITCHELL, G. B.,	Jan., 1885,	_____
MOORHEAD, M. K.,	April, 1881,	_____
MCCUNE, JOHN D.,	Feb., 1881,	_____
MCDONALD, HUGO,	Dec., 1880,	_____
PADDOCK, JOS. H.,	Feb., 1883,	_____
PARK, JR., JAMES,	Jan., 1880,	April 21
QUINCY, W. C.,	Jan., 1880,	Feb. 3
RENO, J. H.,	_____, 1880,	Aug. 5
SCOTT, JAMES B.,	Sept., 1890,	Feb. 13
SMITH, DAVID W.,	_____, 1880,	May 24
STEVENSON, D. A.,	May, 1883,	Jan. 8,
STEWART, D. A.,	Nov., 1885,	Dec. —,
STILLEY, HORACE,	Feb., 1883,	Dec. 19,
STOUFFER, B. W.,	March, 1884,	_____ -
THAW, JR., WM.,	Dec., 1881,	Sept. 3,
VEEDER, HERMAN,	June, 1893,	_____ -
WALKER, HEPBURN,	May, 1892,	Oct. 9,
WASELL, E. D.,	Nov., 1885,	_____ -
WEEKS, JOS. D.,	Jan., 1880,	_____ -
WICKERSHAM, S. M.,	May, 1880,	March 15,
WOOD, JR., B. L.,	Jan., 1884,	March 5,

EXCHANGES.

- ACADEMY OF NATURAL SCIENCES, PROCEEDINGS OF THE, Philadelphia, Pa.
 AMERICAN CHEMICAL SOCIETY, JOURNAL OF, Easton, Pa.
 AMERICAN ELECTRICIAN, Havemeyer Bldg., N. Y.
 AMERICAN ENGINEER, CAR BUILDER AND R. R. JOURNAL, Morse Building, New York.
 AMERICAN INSTITUTE ELECTRICAL ENGINEERS, TRANSACTIONS OF THE, 1009 Havemeyer Bldg., 26 Cortlandt St., N. Y.
 AMERICAN INSTITUTE OF MINING ENGINEERS, TRANSACTIONS OF THE, Lock Box 223, New York.
 AMERICAN JOURNAL OF RAILWAY APPLIANCES, 411-413 Pearl St., New York.
 AMERICAN MANUFACTURER AND IRON WORLD, Pittsburg, Pa.
 AMERICAN SOCIETY OF CIVIL ENGINEERS, TRANSACTIONS OF THE, 220 W. 57th St., New York.
 AMERICAN SOCIETY OF MECHANICAL ENGINEERS, TRANSACTIONS OF THE, 12 West 31st St., New York.
 ANALYST, THE, London.
 ANNALES DE L'ASSOCIATION DES INGENIEURS SORTIS DES ECOLES SPECIALES, DE GAND, Boulevard Friere-Orlan, 6. Argentina, Gand (Belgium).
 ANALES DE LA SOCIEDAD CIENTIFICA, Buenos Ayres.
 ANTHRACITE COAL OPERATORS' ASS'N, 26 Cortlandt St., N. Y.
 ASSOCIATION OF ENGINEERING SOCIETIES, JOURNAL OF, 257 S. Fourth St., Philadelphia, Pa.
 ASSOCIATION OF PROVINCIAL LAND SURVEYORS, Toronto, Canada.
 BOSTON SOCIETY OF CIVIL ENGINEERS, 715 Tremont Temple, Boston, Mass.
 BRICKBUILDER, THE, 85 Water Street, Boston, Mass.
 BUILDING, ENGINEERING AND MINING JOURNAL, Sun Bldg, Queen St., Melbourne.
 CALIFORNIA STATE MINING BUREAU, San Francisco, Cal.
 CANADIAN ELECTRICAL NEWS, Toronto, Canada.
 CANADIAN SOCIETY OF CIVIL ENGINEERS, TRANSACTIONS OF THE, 112 Mansfield St., Montreal, Canada.
 CHEMICAL NEWS, THE, 6-7 Creed Lane, Boy Court, Ludgate Hill, London, Eng.
 CIVIL ENGINEERS' CLUB OF CLEVELAND, THE, Cleveland, O.
 COLORADO SCIENTIFIC SOCIETY, THE, Denver, Colorado.
 DEUTSCH AMERIKANISCHEN TECHNIKER-VERBANDES, Washington, D. C.
 ELECTRICAL ENGINEER, 120 Liberty St., New York.
 ELECTRICAL ENGINEERING, 214 Monroe St., Chicago, Ill.
 ELECTRICAL REVIEW, 41 Park Row, Times Building, New York.
 ELECTRICAL WORLD, THE, 253 Broadway, New York.
 ENGINEER, THE, 43 Cedar St., New York.
 ENGINEERING, 35-36 Bedford St., Strand, London, W. C.
 ENGINEERING AND MINING JOURNAL, THE, 253 Broadway, New York.

- ENGINEERING NEWS, Tribune Building, New
ENGINEERING RECORD, THE, 277 Pearl St., New
ENGINEERS' CLUB OF PHILADELPHIA, PROCEEDINGS OF THE,
1122 Girard St., Philadelphia
ENGINEERS' CLUB OF ST. LOUIS, THE, 1600 Lucas Place, St. Lou
ENGINEERS' SOCIETY OF WESTERN NEW YORK, Library Place, Buffalo
FIELD COLUMBIAN MUSEUM, Chicago
FOUNDRY, THE, Detroit,
FRANKLIN INSTITUTE, THE JOURNAL OF, 18 S. Seventh St., Philadelphia
ILLINOIS STATE MUSEUM, BULLETIN OF THE, Springfield
ILLUSTRATED OFFICIAL JOURNAL (PATENTS), THE, London, W. C
INDIANA ENGINEERING SOCIETY, Cloverdale, In
INSTITUTION OF CIVIL ENGINEERS, (excerpt Minutes of) PROCEEDINGS OF
25 Great George St., Westminster, London,
IOWA SOCIETY OF ENGINEERS AND SURVEYORS, Cedar Rapids,
IRON AGE, THE, 96-102 Reade St., New
IRON & STEEL, 1190 Caxton Building, 334 Dearborn St., Chicago
IRON & COAL TRADES REVIEW, 222-225 Strand, London,
IRON AND STEEL INSTITUTE, PROCEEDINGS OF Victoria St., London,
IRON TRADE REVIEW, Cleveland,
KANSAS UNIVERSITY QUARTERLY, THE, Lawrence, K
LOCOMOTIVE, THE, Hartford,
MASSACHUSETTS HIGHWAY ASSOCIATION, JOURNAL OF, Boston,
MECHANICAL WORLD, New Bridge St., Manchester, Eng
MINING BULLETIN, THE, Pennsylvania State College, State Colleg
MODERN MACHINERY, Ashland Block, Chicago
MUNICIPAL ENGINEERING, Indianapolis
NORSE TEKNIK TIDSKRIFT, Christ
PHYSICAL REVIEW, THE, Ithaca,
POWER, Rms. 145-146 World Building, New
PURDUE SOCIETY OF CIVIL ENGINEERS, PROCEEDINGS OF,
Purdue University, Lafayette
RAILWAY AGE, THE, 1000 1004 Monadnock Block, Chicago
RAILWAY AND ENGINEERING REVIEW, 818 "The Rookery," Chicago
REVISTA DE OBRAS PUBLICAS E MINAS, Lisbon, Port
ROADMASTER AND FOREMAN, 91-93 Jefferson St., Chicago
SCHOOL OF MINES QUARTERLY, COLUMBIA UNIVERSITY, 41 East 49th St.,
SCIENTIFIC AMERICAN, New
SMITHSONIAN INSTITUTION, Washington,
SOCIETY OF ARTS, JOURNAL OF, John-street, Adelphi, London, I
SOCIETY OF CHEMICAL INDUSTRY,
Palace Chambers, 9, Bridge St., Westminster, S. W., Lon
STEVENS' INDICATOR, THE, Stevens' Institute of Technology, Hoboken,
STREET RAILWAY, REVIEW, 890 Old Colony Building, Chicago
SVENSKA TEKNOLOGFÖRENINGEN, Stockholm, Swe

TECHNICAL SOCIETY OF THE PACIFIC COAST, THE,	
Room 56 Academy of Sciences, San Francisco, Cal.	
TECHNIC, THE. ENGINEERS' SOCIETY OF THE UNIVERSITY OF MICHIGAN,	
	Ann Arbor, Mich.
TECHNOLOGY QUARTERLY,	Mass. Institute of Technology, Boston, Mass.
TEKNISKE TIDSKRIFT,	Stockholm, Sweden.
TIN AND TERNÉ AND THE METAL WORLD,	
	Room 705 Publication Bldg., Pittsburg, Pa.
UNIVERSITY OF CALIFORNIA,	
	Berkley, Cal.
UNIVERSITY OF WISCONSIN, BULLETIN OF,	
	Madison, Wis.
UNITED STATES BUREAU OF EDUCATION,	
	Washington, D. C.
UNITED STATES DEPT. OF THE INTERIOR,	
	Washington, D. C.
UNITED STATES DEPT. OF AGRICULTURE,	
	Washington, D. C.
UNITED STATES GEOLOGICAL SURVEY,	
	Washington, D. C.
UNITED STATES PATENT OFFICE, THE OFFICIAL GAZETTE OF THE,	
	Washington, D. C.
UNITED STATES WAR DEPARTMENT,	
	Washington, D. C.
WESTERN ELECTRICIAN,	
	Chicago, Ill.
WESTERN RAILWAY CLUB,	
	"The Rookery," Chicago, Ill.
WESTERN SOCIETY OF ENGINEERS, JOURNAL OF THE,	
	1737-9 Monadnock Block, Chicago, Ill.
YALE SCIENTIFIC MONTHLY, THE,	
	New Haven, Conn.

JOURNALS SUBSCRIBED FOR.

AMERICAN CHEMICAL JOURNAL,	
	Baltimore, Md.
CASSIER'S MAGAZINE,	
	World Bldg., New York.
ENGINEERING MAGAZINE,	
	New York.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

EIGHTEENTH ANNUAL MEETING.

January 18th, 1898.

The Eighteenth Annual Meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the Society's House, 410 Penn avenue, Pittsburg, Pa., Tuesday evening, January 18th, 1898. The meeting was called to order at 8:20, Mr. Emil Swensson in the chair, and thirty-three members and visitors being present.

The minutes of the last Annual Meeting were read and approved.

Prof. A. E. Frost, Treasurer of the Society, read his Annual Report, which is as follows:

REPORT OF THE TREASURER,

For the year ending January 18th, 1898.

RECEIPTS.

1897, January 19th.

Balance.....			\$ 149 95
Dues to January, 1895.	1 at \$5.00.....	\$	5 00
" " " 1896.	6 " 5.00.....		30 00
" " " 1897.	14 " 5.00.....		70 00
" " " 1897. $\frac{1}{2}$ yr.	2 " 2.50.....		5 00
" " " 1898.	50 " 5.00.....		250 00
" " " 1898. $\frac{1}{2}$ yr.	1 " 2.50.....		2 50
" " " 1899.	1 " 5.00.....		5 00
" " " 1895.	5 " 7.00.....		35 00
" " " 1896.	18 " 7.00.....		126 00
" " " 1897.	47 " 7.00.....		329 00
" " " 1897. $\frac{1}{2}$ yr.	1 " 3.50.....		3 50
" " " 1898.	241 " 7.00.....		1,687 00
" " " 1898. $\frac{1}{2}$ yr.	4 " 3.50.....		14 00
" " " 1899.	1 " 7.00.....		7 00

Dues on account.....	4 00	
Initiation fees. 30 at \$5.00.....	150 00	
From rent of rooms in Society House.....	847 00	
" advertising contracts.....	265 00	
" sale of Proceedings.....	39 41	
Special contribution to library.....	3 00	
Total.....		3.
		<u>\$4.</u>

EXPENDITURES.

Salaries.....	\$ 578 75	
Office expenses.....	238 73	
Rent	1,500 00	
Fuel and light.....	127 73	
Printing	1,085 43	
Periodicals.....	101 35	
Safe	43 00	
Gas stove	43 45	
Holophane globes.....	10 05	
Welsbach burners.....	49 15	
Plumbing	7 50	
Illustrations in Proceedings	47 00	
Stereopticon.....	16 00	
Stenographer.....	83 40	
Water tax.....	56 18	
Total.....		\$3,9
Balance		\$
Total.....		<u>\$4,0</u>

Respectfully submitted,

A. E. FROST, *Treasurer*

It was moved and seconded that the report be accepted as read. Passed.

Attention was called to the following points: That the bills carried over from 1896 to 1897 amounted to about \$410.00, while the bills carried over from 1897 to 1898 were only about \$208.00; that back dues collected in 1897 amounted to about \$260.00 against \$602.00 in 1897; that the rent in 1897 was \$1,500.00 against \$1,125.00 in 1896.

that dues collected for 1896 were about \$1,695.00 against \$1,953.00 for 1897; that back dues for 1896, not paid, were about \$221.00, and for 1897 were about \$388.00, or a total of \$609.00; that receipts for rent from third and first floors were in 1896 \$523.00 against \$847.00 in 1897.

The Secretary then read his Annual Report, which, upon motion, was also accepted:

SECRETARY'S REPORT.

Membership on Jan. 1st, 1897.....	374
At the Annual Meeting, Jan. 19th, 1897, twenty-one (21) names dropped from the roll.....	21
Sixteen (16) resignations, and three (3) deaths reported during the year.....	19
	<hr/> 40
During the year seven (7) of the applicants elected members of the Society in 1896 matriculated; and twenty-six (26) applicants were elected members of the Society during 1897, and of these twenty-four (24) matriculated.....	31 9
	<hr/>
Membership on Jan. 1st, 1898.....	365

The average attendance at the monthly meetings during the year was forty-eight (48).

Respectfully submitted,

REGINALD A. FESSENDEN, *Secretary.*

Reporting for the Board of Direction, the Secretary read a list of thirteen names of members recommended by the Board to be dropped from membership. It was moved and seconded that the names read be dropped from the rolls, in accordance with the recommendation of the Board. Carried.

Mr. Gustave Kaufman, for the Library Committee, reported that they had found that there was still a good deal to be done in the library, that the unbound volumes had to be arranged for binding, that these had been arranged, and that there were about 100 volumes at the binder's at the present time, being bound, and that the cost would be about \$60.00. He also reported that the commit-

tee had made up a card index case catalogue of all books in the library, that same would be sent to the Society Rooms, and that they had recommended to the Board that two new cases be bought, as the accommodations for the books were not sufficient; that they had received a bid of \$40.00 per case on two cases, but thought this amount was too much, and that they had not ordered same. He also said that he believed that the work of buying new cases should be put in the hands of the House Committee.

Moved and seconded that the report be accepted. Carried.

Mr. W. A. Bole, for the Programme Committee, said that the committee was very glad that their work was finished and the year was over.

Moved and seconded that the report be accepted. Carried.

House Committee made no report.

Mr. Engstrom, for the Reception Committee, reported that the Annual Banquet would be held at the Hotel Henry as announced, and that any members wishing tickets could get same either from the Secretary or any of the members of the Reception Committee.

Moved and seconded that the report be accepted. Carried.

Mr. J. K. Lyons, for the Auditing Committee, reported that the committee had found the accounts of the treasurer correct as read.

Report accepted.

Mr. G. S. Davison, for the Constitution Committee, reported that the committee was ready at any time to hold a meeting to settle the matter, but that at the present time their report was on the table.

Report accepted.

The President then read his Annual Address: "The Economic Function of the Engineering Profession, and Lessons taught by the late Business Depression."

To the members of the Engineers' Society of Western Pennsylvania :

GENTLEMEN:—The few remarks which a retiring President, by custom, is obliged to inflict upon you may perhaps be styled his “valedictory,” and as you did not furnish me with a topic, you will have to be lenient with your criticisms, and accept the consequences of your failure to do so.

The difficulty encountered in selecting a subject is at any time, under the most favorable conditions, trying, and I, in this instance, in consequence of the diminished activity in engineering, found it particularly so, and occupied so much time in selecting that on which to address you, that I have had very little time to devote to the selection and elaborate upon, “The economic function of the Engineering profession, and the lesson taught by the late business depression.”

Pardon me for departing from the lines established by my honored predecessors in their addresses upon retirement from this office, which have been eulogistic of the profession, calling attention to noted achievements during the preceding year by our fellow-members, or the profession at large, which certainly are very valuable in spurring others to future action, and to endeavor to surpass, or at least equal them, in the years to come, but we must not be unmindful that failures of ourselves or others, often more than our successes, teach great lessons for future guidance and action. It occurred to me that possibly we could learn something from the failure of this country in the last few years commercially to enhance its position as the foremost in material progress, development, and consequent engineering activity, having now dropped to the competitive level of the world at large, and by scrutinizing the situation it may teach us some valuable lessons for our guidance in taking advantage of the new condition.

The successes of the country in the past has been due mainly to the development of our unbounded natural resources and the settlement of new territory, (not to this or that political

belief) with resulting great rewards for both capital and labor, but as the country became more settled our power of production became greater, and when practically all new territory had been taken up and settled, our production became greater than our needs, with resulting drop in prices and reduced rewards, both of capital and labor. This state of conditions means that we must dispose of our surplus to other nations, and to do this we must be able to sell our products for a lower figure than other nations producing the same article. With our high rates of labor wages, and the higher rates of interest demanded by capital, it is a rather difficult problem to solve, and must be overcome by greater energy of labor, the devising of means and machinery for the saving of time of labor, which again means increased production, and economy in material and supplies. In other words we now have entered upon an era of *small* economies, and the strictest systematizing in everything pertaining to our products and handling of labor and materials has become a necessity. In the past this country has been a promised land to all people with great energy and well developed ideas of how to *get there* in the quickest and shortest possible manner, as the rewards resulting were so great that the means used, or their costs, were not of great moment, so long as they brought quick returns to capital. Under such conditions the Engineering profession became more of a trade than a profession, and was only used as a tool, necessary to the hands of capital or its managers to devise means to carry out their plans and schemes in the shortest time, often regardless of first cost and subsequent cost of operating. This great rush and eagerness to produce results naturally soon led to more or less carelessness in execution and disregard of quality of product, which in turn, before long, was followed by a healthful reaction, and the Engineers began specifying and demanding better qualities and workmanship, which gradually raised the standard of the work and products, but only as fast as the cost of so doing would permit. The

other extreme was soon reached, however, and many of the Engineers began making such radical demands that the manufacturer could not follow them, even at increased cost, and *if* the demands could be complied with at an increased cost, often the client of the Engineers had to foot said increased cost, but just as often the manufacturer had to sustain a loss. In either case the profession ultimately suffered from such conditions, the same as is always the case when one is too far ahead of, or behind the times. Especially so is that the case when the clientage discovers that their technical adviser is losing sight of the economic feature of his profession in his eagerness to establish a technical reputation for, or build a monument to himself. Strained relations between the profession and the manufacturer and the contractor became the order of the day, when in fact their common interest should be to produce the best results suited to existing conditions for the least cost and expenditure of energy, as then they are as they should be, true and economic factors in the great household of mankind.

I am afraid that the late business depression, and the resulting drop in prices, will widen the breach rather than close it up, as manufacturers and contractors are so anxious to procure work that they are ready to agree to and promise nearly everything demanded by the Engineers, and they in turn see a chance to introduce their various schemes, fads and notions without any objection being made or extra price being asked. But let the American Engineers take warning from the present conditions in England, where the profession and various boards with laws, rules and restrictions have so loaded down and hampered the manufacturers that they are now unable to compete with those of Germany and lately the United States. On the other hand, it is, of course, true that as the years rolled by, the United States became more settled, and competition increased with consequent reduction in prices and profits, the question of economy became more prominent, and naturally

the large economies were first taken up by capital itself and its managers, such as first cost, reduction in numbers and salaries of operating employes, and consolidation or pooling of interests, thus reducing cost of management. But we have, during the past few years, come to the point where the above is not sufficient, and the manufacturers must begin the practice of small economies, constantly bearing in mind that "a penny saved is a penny earned." Here is where the true function of the Engineering profession comes into play, and the Engineer, who is equal to the occasion, will reap his just reward.

The first move towards this end is for the Engineer to fully and fairly consider the side of the manufacturer and contractor; and get into closer touch with them, and thus be enabled to study in their minutest details the means, processes, and practices employed to produce the desired result, and then through the medium of an analytically trained mind, in which respect the Engineer is better equipped than the business man and manager, improve on said means, processes, and practices, and further by the devising of new systems, processes, and machinery cheapen the cost of production, of course without affecting the quality of work or product, except possibly for the better.

The man who thus, for example, can devise means for economy in machine shop practice; for the greatest economy and efficiency in utilization of energy in steam, compressed air and water, and electricity; for the closest recording of time, thereby compelling close attention on the part of the workman to work in hand; for the quickest and easiest handling of material; for the saving in operation, supplies and tools; for dispensing with refinements either absolutely useless or not enhancing the quality commensurate with the outlay; for the increase of speed and carrying capacity of freight lines, with none or only slight increase in operating expenses (not forgetting highways and streets); for increased output per man per hour, other factors remaining equal, etc. will be speedily recognized by the manufacturer and contractor

By enlisting our powers in the directions indicated above we will materially assist the manufacturer especially, as well as the country as a whole, to prepare for the struggle for our share, which should be the "lion's" share of the business of the world, when we consider our natural resources, energy and inventive genius.

Another field wherein the profession should be of incalculable aid to our country is now opened since the doors of the world's commerce are standing slightly ajar for us—we should acquaint ourselves with the needs and requirements of the various countries in quest of such wares as we can supply, educate them to our ideas and standards, illustrating their superiority over other methods, at the same time catering as far as is consistent to their own notions and wants. By so doing the Engineers will be in excellent position to advise the manufacturers just how to proceed, both in a technical and business way, and thus enable them to meet, not only the requirements of the prospective customers, but also the price of our competitors, and before long the doors of the world's commerce will be standing wide open, the engineering profession thus becoming the successful, well-rewarded and honored intermediary. This course of action I consider the opportunity of the younger consulting engineer.

But this will never work. I hear somebody say. Just look at what is being done to-day; the manufacturer and contractor employs his own engineering talent and furnishes the same free of charge to the customer, thus discouraging the engagement of independent or consulting talent. True; but whose fault is it? Should the profession come closer to the manufacturer and contractor, or forever endeavor to be far ahead of existing conditions, always trying to surpass his brother engineers with some new requirement, or a notion or fad based on theoretical deduction without any special regard for the additional cost it will impose on the contractor, and without any commensurate increase in quality?

In the matter of bringing foreign work into this country and obtaining the highest possible price for same, it is interesting to note that, although the manufacturers of the United States are sending both engineers and business men into foreign lands to get familiar with their wants, resources and the prices obtainable for our goods, the independent and consulting engineers of the United States are doing practically nothing in this direction; but, on the other hand, the foreigners have not been idle, as they, including even Japanese and Chinese, have been and are continually coming over here gathering all kinds of information, and have even now established agencies, independent and otherwise, in this country, which obtain our lowest figures and sell at advanced prices *unknown* to us. This middleman's profit, which is usually large, should rightly belong to our profession, just as it for so long has been reaped by the English engineers, who now, however, seem to have dug their own grave through their rigid and conservative safeguards. In this respect it will not be amiss to call your attention to the success of the Germans in introducing new ideas and methods, and thus selling their goods in markets heretofore monopolized by the English. Yes! England has been invaded successfully by the Germans, and I see no reason why the goods of the United States should not also invade, not only South America, Asia, Africa, and Australia, but England, and even Germany, as well as the rest of Europe. But it is with regret we note that very few of our engineers see the signs of the times, and instead of following the broad and liberal policy of anything and everything American, they seem, at any rate in some branches of the profession, to be imbued with a desire to adopt English ideas and methods as embodied in time-honored, or rather time-worn rules and regulations of various established boards. Let us be true and progressive Americans, and proclaim to the world as one of our mottoes, "We abhor waste of time, labor and material." Let us, therefore, be careful in making up

our specifications that we do not violate this motto by the introduction of useless and costly refinements, requiring certain *methods* or *procedures*, when calling for *results*, will do as well: but especial care should be exercised that we do not demand and insist upon minor points simply to get an opportunity to display our authority, and further advising but not specifying economic features, when we know of any, that we may become more and more able to supply the wants of the nations of the earth, which, with our natural resources, is our unquestionable destiny.

In conclusion, congratulations to the Society are in order on a successful and interesting year, and on the fact that notwithstanding all manner of dire predictions, it is still abundantly able to sustain itself in a comfortable house of its own. Further, I wish to thank the Society for its courtesies and its forbearance with my numerous shortcomings as President, and lastly thank the officers and Board of Directors for their support and assistance during my incumbency. Wishing continued success to the society, I now venture the prediction that 1898, under the guidance of the new officers, will not only be a successful but a brilliant year.

Long live and prosper the Engineers' Society of Western Pennsylvania!

EMIL SWENSSON.

The election of officers for the ensuing year then took place.

The President then read the names of the nominees and asked if there were any further nominations.

After it was voted that the nominations be closed, Messrs. Lyons and Wendt were appointed tellers.

Thirty votes were cast and the following named nominees were declared unanimously elected:

For President, one year, Geo. S. Davison.

For Vice-President, two years, W. A. Bole.

For Directors, two years, C. F. Scott and Gustave Kaufman.

For Secretary, one year, Reginald A. Fessenden.

For Treasurer, one year, A. E. Frost.

It was moved and seconded that the Annual Meeting adjourn. Carried.

Mr. G. S. Davison, the new President, then took the chair.

REGINALD A. FESSENDEN,
Secretary.

PITTSBURG, PA., January 18th, 1896.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the lecture room of the Society's House, 410 Penn Avenue, Pittsburg, Pa., Tuesday evening, January 18th, 1898, the President, Mr. G. S. Davison, being in the chair. The meeting was called to order at 9:20 P. M., 30 members and visitors being present.

The minutes of the last regular meeting were read and approved.

For the Board of Direction, the Secretary then read the following names of applicants, passed by the Board and recommended for ballot at the next regular meeting:

Abraham Gross, Student at the Western University of Pennsylvania, Allegheny, Pa.

Tillman D. Lynch, Assistant Inspector of Steel for the United States Navy, Munhall, Pa.

The following applicants for membership were then balloted for, Messrs. Hirsch and Schade being the tellers, and were declared duly elected:

William M. Taber, Assistant Sales Agent, Pittsburg Office Sterling Company, Pittsburg, Pa.

Harry Heffrin, Erecting Engineer and Draughtsman, 812 Lewis Block, Pittsburg, Pa.

Henry F. Miller, Mechanical Engineer, with National Tube Works Co., McKeesport, Pa.

David L. Moorhead, Civil Engineer and Surveyor, Indiana, Pa.

Wm. J. McAllen, Draughtsman, with Pittsburg Bridge Co., Pittsburg, Pa.

J. Mont. McCrickart, Mining Engineer, with Selwyn M. Taylor, 420 Bissell Block, Pittsburg, Pa.

Charles T. Rainey, Mining Engineer and Map Publisher, 113 Water St., Pittsburg, Pa.

Samuel A. Taylor, Civil and Mining Engineer, 339 Fifth Ave., Pittsburg, Pa.

By request, the President, for the Constitution Committee, gave a brief history of the work that had already been done on the constitution, after which there was some discussion as to the advisability of taking the report from the table long enough to take further action on the matter.

Mr. F. Z. Schellenberg, for the Committee on Roads, read a third report of the committee, and requested that same be printed in the December Proceedings of the Society, so that the three reports would come in the same yearly volume.

It was moved and seconded that the report be accepted as read and be printed in the Proceedings as per suggestion.

Upon motion the meeting adjourned.

REGINALD A. FESSENDEN,
Secretary.

CHEMICAL SECTION.

PITTSBURG, PA., Jan. 20th, 1898.

The Sixth Annual Meeting of the Chemical Section of the Engineers' Society of Western Pennsylvania was held Jan. 20th, 1898.

Vice-Chairman K. F. Stahl presided.

The Minutes of the last Annual Meeting were read and approved.

The Secretary reported as follows :

Number of meetings held,	-	-	10
Number of papers read,	-	-	11
Average attendance,	-	-	15

Dr. F. C. Phillips, for the Sanitation Committee, made a brief report.

A letter from the Chairman, W. E. Garrigues, was read regretting his inability to attend the Annual Meeting, owing to absence from the city.

The election of officers for the ensuing year followed, ballots being distributed and the following officers being unanimously elected:

Chairman, J. O. Handy.

Vice-Chairman, Walther Riddle.

Secretary, A. G. McKenna.

Directors, K. F. Stahl, W. E. Garrigues.

Mr. J. O. Handy, the new chairman, then took the chair. Annual Meeting adjourned.

A. G. McKENNA, *Secretary C. S.*

PITTSBURG, PA., Jan. 20th, 1898.

The regular Monthly Meeting followed the Annual Meeting.

Chairman, J. O. Handy.

The Minutes of the last regular meeting were read and approved. Mr. J. O. Handy read a review of the chemical literature of the year of interest to chemists of the Section, which was briefly discussed.

The Section adjourned at 10.30 P. M.

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A. G. McKENNA, *Secretary C. S.*

FOURTH REPORT OF THE COMMITTEE ON ROADS.

TOPOGRAPHY BY F. Z. SCHELLENBERG.

In Pennsylvania the topography is so marked with the parallel mountains coursing east of north and turning more east as we go north, as to indicate a central source of force in the ocean to the southeast, whence this part of the Appalachian chain's form was profoundly modified if not originally determined. And going westward the ridges are repeated with gentler slopes into the state of Ohio.

The shores of New Jersey, the bays south, and our shore line on Lake Erie trend with the mountains.

So our rivers' courses are parallel, alternating with square-off cross-cuts through the gaps. And on maps we make of tracts of land away from the mountains we find even the small streams a succession of right-angled bends that tell of the strike and dip of the rocks, though this be a gentle fall with few exposures at the surface in direct indication of it.

We see the Delaware in its entire course a series of right angles, with long and generally straight stretches between; three such salient points are at the head of tidewater (near Trenton), Stroudsburg and Port Jervis. On the Juniata the Pennsylvania Railroad has its most northerly point, Tyrone, at such an apex. Though the Susquehanna, in its middle course, goes directly south, it is with rapid fall through the mountain gaps there near together; and though the Monongahela goes north, it is with slow fall against the general rise of the rock measures, its bends in the detail conforming to the rule, any exceptions being in the synclinal valleys where, too a small stream will stagger about and make grotesque sinuosities through the flat alluvium.

Northeast and northwest, but not in very long straight lines, run the co-ordinates of our topography that is founded with no exceptions in Western Pennsylvania on the arches of

the sedimentary rock masses which with us are nowhere deeply covered by the glacial drift; and *a perfected system of highway alignment and of town platting should follow these diagonal arcs rather than the meridians and departures*;¹ for the coercion in direction of our underground drifting—in the coal seam—teaches us that there is advantage in being with the structure of the rocks in excavating at the surface and with their terraces in embanking.

On a moderate as well as the grand scale, therefore, will our according artificial lines find least resistance as fitting to natural ones of the contour: our shaping of the terrain will work with the grain of mother earth.

Such profound reasons for the bearings of roads and streets of a district may not appeal to the superficial man, but the miner of the coal once finding the shape in imaginary lines of the subterraneous framework, we know, does not grope planless any more than does the mariner looking to the stars to shape his course. It is well to remind the rest that it was through the coal miner's devising came the steam engine (stationary and locomotive) and the railroad, all of which other men have found put to use so variously and widely as to forget the origins of the great development that has revolutionized mankind; and as the dial and the compass associate the early miner with the seaman, so it is well next to credit the men of commerce by water as adopting steam power in a large way before the slower landsman recognized means and ends for himself.

But the grain of our rocks is not now, in regular long lines, always with their present stable position defined by

¹ It is noteworthy that in our cities where the system of streets was laid out according to the cardinal points, the *avenues* so run diagonally, being the old roads that were steered for important points upon natural routes beforehand. In Washington City the *avenues* were laid out diagonally so. In Pittsburg the name *avenue* is not confined to the high ways.

"The general direction of the streets should be such that the greatest number may, during the day be visited by the sunshine. This will be accomplished if one set of parallel streets runs in a northeasterly and southwesterly direction."—City Surveying, in Carharts' Plane Surveying.

their lines of level strike and greatest dip at right angles thereto; in this final rigidity the high and low axes of their trend, by offsets to the left, are pieced *en echelon* and, with undulations, have a general rise northeastward.

The vertical jointing was determined for our coal, we find here regularly, at N. 65 W. for the lines of the faces, and N. 25 E. for the joints, and must date from an anterior time of perhaps merely tidal pulsations of the crust affecting the texture of the coal seam.

What with the crowding from the southeast, corrugating the grouped strata into billows of great arches on broken lines wavering in level, with troughs between, (holding yet some of the upper minerals in basins), and what with the after erosion (we see continuing by frost and water—cutting and filling—) even reversing the order in having courses of the valley of a main stream on or near the line of an anticlinal, and the hills over the synclinal; we have a disguise to penetrate—of not small detail alone—by means of finding the run of a series of level lines of the surface, together with the proving of the rocks where they are altogether hidden, to give us facts (beyond the mere index to theory of general correspondence throughout a region) that local tribulations may not mar or destroy.

Delineating topography as contour lines on *field sheets* that shall serve as a basis of projection for railway or highway location, also mostly in the field, is a most satisfactory as well as healthful exercise. The system was made classic years ago on the rugged surface of Pennsylvania by her railroad-locating engineers. It being simple and direct, a brief description will show the method for the contours superior here, if not in broader flatter lands, to any style of gathered notes and sketches in field book for depicting on paper in the office afterwards aided by memory, or without in second hands.

The experimental line run along a natural route by field transit (the instrument first made by Young, in Philadelphia)

on needle or deflection courses with regular stations one hundred feet apart, as a broken line probably near a fair location, was immediately followed by the Level party (the Philadelphia rod being used on which the red foot marks and black tenths are read through the telescope, of the Leveling instrument) so that in "running to grade" for an extended descent a check might be had on the advancing line to have assurance of sustaining ground for the prospective grade of regular fall.

The topographer's drawing board, on one side of which the sheet in use was tacked, was hollow as a flat box to hold demi-sheets of paper containing successive portions of the line that was run the day before and plotted in the evening, on scale of 400 feet to the inch, and having a couple of digits penciled at each pencil dot (station) of the red inked line to indicate the elevations of all the stations. So he was on the ground ready to get down the contour lines (10 feet rise apart) etc., correctly on the plot as they appeared from his assistants measuring the slope of cross section, in parts of different rates of rise or fall and corresponding distances, at each station, etc., and with a mind free as to the future; there being only the inking of the pencil trace lines to do when he was with the camp chest on a rainy day.

His drawing instruments were the protractor, parallel ruler, and scale. Sometimes it happened in contingencies that he plotted line in the field from fresh notes (of line and of levels) left behind, stage by stage for him.

These contoured experimental line sheets of a long survey served afterwards—on a distinct continuous locating trip—to project the location line of curves and tangents upon, piece by piece (on the ordinary, rougher, ground always in the field and connection being made at the end of each piece located with the experimental on the ground, to test the outcome of the projection, each piece of projected location started from point on plot fixed by tie to the experimental, though the location on ground was of course run consistent with itself. Thus were

eliminated discrepancies and comparison kept step by step between the lines, on so small scale a drawing.

Profile of either line was also kept up as required in the field, by adding portions of the elevations on line from the notes of levels just taken.

The location line plotted on new sheets day by day had its topography made anew on the very ground, and the progress of the survey being then slower than before, the topographer had time for free hand drawing of the larger features in sight to appear as embellishments on the continuous tracing map made in the office; and he could pay some attention to land division lines.

There were also on each line some triangulations in his aid made with the survey and noted for his plotting, as of intersecting sight lines to prominent points on opposite shore of river. There is suggestion here for topographic work in wide open areas to have the use of the Plane table in getting a map directly in the field, or of the older plainer Traverse table on which a loose alidade, as a ruler carrying an upright sight at each end, is used for drawing lines of sight on the sheet to fix the position of points off the base line by line of sight and measurement, or from two or more stations of it by intersecting lines of sight, the base line being a regularly surveyed one plotted in advance on the sheet, and not as with the Plane table which has the assumed capacity of taking independent position between determined lines, having a compass box attached for its orientation and the loose ruler carrying a telescope, fixed in azimuth with it, containing Stadia wires.

A Traverse table on open flat land can take every single object in sight and can make a new base to work from after two or more outside points in view from each other have been located on the sheet by graphic triangulation, and thus may be made in quickest way to depict subdivisions of the land into cultivated fields with the crops indicated, woods of different growths, the margin of swamp land, stream with the

islands, etc., as well as buildings accurately as the dimensions of ground plans are taken by direct measurement. And, of course, may receive delicate lines of level contours where there is a basis of spirit-levelled elevations, though in this again the Plane table would seem to have a wider scope of approximate accuracy. Either instrument stands in the field levelled on a tripod at easy height for working upon and clamped to fix its relative position in place, as a drawing table 20"x24", and in good hands it serves for mapping natural and artificial details as no office work can after notes and sketches, even if these had the aid of pocket sextant or compass with measurements or pacing and recollections at first hands.

If contouring in extended areas has not the bases afforded by levels run after survey of boundaries, sub-divisions, road traces, etc., principal traversing contours may be staked at even fifties or hundreds above the datum of elevations (as by levelling instrument and chain leading, the taking of bearings following). Between such located contours on the ground the determining of the spacing at each cross section for intermediate ones is obviously simple.

Or, in the first place, the elevations may be carried around the survey, derived by use of vertical limb on combined instrument (transit with level) and stakes be interpolated marking crossings of such principal contours. And with stadia wires in the telescope, the instrument, sighting in graduated rod, has the grasp in one operation afterwards to fix the level traverse of a principal contour. According to the nature of an area it may be a very satisfactory way to run the lines and levels of a divide, its crest line and spurs, and the same tracing the water courses; and so have the position of high and low elevations between which to contour the slopes by cross sections.

The singular case of getting the contours of a piece of mountain forest (9,000 acres at Biltmore, N. C.) for situation

plan, is instructively described by John L. Howard, of Boston :²

Cross sections were taken 500 feet long between parallel branch lines, staked and levelled every 100 feet, which ran at right angles with a principal line, straight and centrally located with 500 feet apart, starting hubs (plugs) for zeros of two sets of branch lines that were run in opposite directions, the Locke hand level and speaking rod being used for cross sectioning. Profile sheets of the branch lines carried into the field gave the starting and ending elevation of each cross section: the like numbered stakes of the two lines, between which the distance of each 10-foot contour was directly taken by pacing and noted.

To get the topography for working plan of a new town site upon which to project streets, blocks of lots, sewerage, etc., the practice is the surveying of a network of 100 foot squares and taking accurate levels. The monuments set for street lines may make a different scheme to guide position of improvements in their building. In park and cemetery work, to be plotted on good scale, contours may be taken at 5-foot and even 2-foot rises, and thrifty natural trees that should remain be tabbed and brought to paper.

For taking the data for the cross sections on survey lines, the earlier practice was with the Clinometer and 10-foot slope pole. Later came into use the slope board, home-made, and with a small lead plummet on silk string hanging from a staple in its side, its arc, like the others, being an even degree graduation of the quadrant; this board having the advantage of use in sighting along its edge at height of the eye from man to man, as well as getting the inclination when laid on edge of slope pole. The topographer had a paper scale, made by himself, of horizontal distance for 10 foot rise at every degree.

It was an improvement to substitute for the even gradu-

² Topographical Surveys—Methods Used on the Vanderbilt Estate at Biltmore, N. C., in *Journal of the Association of Engineering Societies*, April, 1897. See also in same the valuable contribution by Henry F. Bryant, *Topographical Surveys of the Metropolitan Park Reservations of Massachusetts*.

ation of slope instrument the spacing of arc for consecutive horizontal distances of 10 foot rise, and so denoting the spacing.

Angular cross-sectioning, proposed more particularly for determining rock excavation sections—by length of tape stretched in line of sight of transit instrument, and giving according to the vertical angle the horizontal and vertical components of this basal angle and that hypotenuse—suggested a mode of graduation for determining contour points from measurements along the slope, and a table is given in Carhart's Plane Surveying for graduating any vertical arc to give rises from one to one hundred for one hundred on the slope. Stadia reading of these distances would not require correction.

The Locke hand level has come into very general use, and, if kept in adjustment, good work can be done with it.

The relation between stratigraphy and the character of the surface topography, so apparent on the grand scale in our State and perceptible in the detail, certainly affected our railroad engineers in their surveys, unconsciously, as they were governed by the streams and the summits. The principle was to stay with the stream until forced from it by the consideration of scaling the divide, the first cost of construction rather than the operation of the road being the economical idea, they got crooked lines and not always good grades. It was an injunction not to distribute the fall between points far apart for the sake of an average low gradient, because the running to grade would carry you out of the immediate valley, although here you did not exactly conform in line and fall to every short change of the lower ground either.

In important cases they ought to have built bridges, had better alignment, and controlled both sides of the valley.

Before the day that higher gradients were admissible, the canal engineer, in building his portage railroad, had the instinct to find his way along the favoring benches of the rock measures at gentle change in level, with generally tolerable

cross slopes, in getting from one inclined power plane to the next, and also in locating these to be on land favorable transversely.

The railroad engineer building laterals after the mineral—being bold in gradient if not in grading—conventionally stayed with the stream in its tumbling courses through the series of the column of the measures, even turning its channel and filling across its bed; he avoided high crossings of ravines and valleys.

But the years of long underground hauling, etc., to the enforced outlet where mine and railroad were conjoined—perhaps even then by extra surface machinery—were not reckoned with in advance.

And scarcely yet do we see the railroad development by a branch thoughtfully laid through a coal district, counterminous outside the basin, or with the general trend, as it may be varying inside the basin.

The whole lesson of the topography is not gotten.



ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The regular monthly meeting of the Engineers' Society was held in the Society's rooms, 410 Penn Avenue, Pittsburg, Pa., Tuesday, February 15th, 1898. The meeting was called to order at 8.30 P. M., the President, Mr. George S. Davison, being in the chair. There were thirty members and visitors present.

After the minutes of the preceding meeting had been read and approved by a vote of the Society, one of the members who had been dropped at the annual meeting, his dues not having been received through accident, was reinstated.

The following applicants were recommended by the Board :

Thos. R. Morgan, late General Manager Morgan Engineering Co., 462 Atlantic Ave., E.E. Pittsburg, Pa.

John McDonough, Master Mechanic, Duquesne Steel Works of Carnegie Steel Co., Duquesne, Pa.

Jno. M. Phillips, Manager, Phillips Mine Supply Co., S. 23d and Mary Sts., Pittsburg, Pa.

Lewis D. Rights, Structural Draughtsman, Shiffler Bridge Co., Pittsburg, Pa.

Nelson C. Wilson, Member of Firm of Wilson & Wilson, Engineers and Contractors, 1012 Carnegie Building, Pittsburg, Pa.

The following gentlemen :

Tillman D. Lynch, Assistant Inspector of Steel for U. S. Navy, Munhall, Pa.

Abraham Gross, Student, W. U. of Pa., 17 Monterey St., Allegheny, Pa.

were then balloted for and declared elected.

It was voted that the regular routine business be suspended until after the reading of Mr. Chester's paper, which was then delivered by the author, and a discussion ensued.

It was voted that the new constitution be taken up from the table, and then voted that a consideration of the new constitution be the order of business at the next regular meeting.

On behalf of the Banquet Committee, Mr. Engstrom reported that it had been a success and the Committee Treasurer, Mr. Johnson, then read the following report :

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

ANNUAL BANQUET, JANUARY 27th, 1898.

Statement of Accounts.

RECEIPTS.

From sale of tickets,.....\$468 00

DISBURSEMENTS.

Hotel Henry for Banquet,.....	\$360 00
R. W. Jenkinson, for cigars,.....	17 50
The "Beobachter," for printing,...	18 00
Pittsburg Photo. Engraving Co., for plates,.....	15 65
Charles Gernert, for music,.....	30 00
A. W. Smith, for flowers,....	15 00
Paid by V. Beutner, for cards,.....	75
	<hr/> \$456 90
	\$ 11 10

Respectfully submitted,

THOS. H. JOHNSON,
Treas. of Committee.

The report was accepted and the thanks of the Society voted to the Committee. Mr. Johnson then suggested that at the next banquet cards should be given to the guests on which they might write their names and addresses so that the succeeding Banquet Committee might have a list of those members who generally attend these banquets.

Mr. Schellenberg, on behalf of the Roads Committee, stated that a fourth report of that Committee had been sent to the Board of Directors for publication, and had been printed in the January Proceedings.

For the Reception Committee, Mr. Beutner reported that refreshments had been provided for by the Committee for the members at the close of the meeting and that it was proposed to make this feature a permanent one, and that the cost of each lunch would be defrayed by the members who partook of it.

The meeting then adjourned and a very pleasant hour was passed in conversation and in partaking of the refreshments, which were then served.

REGINALD A. FESSENDEN,
Secretary.

FIFTH REPORT OF THE COMMITTEE ON ROADS— PROGRESSIVE OPINIONS—THE RELATIONS OF OUR ROCK FORMATION.

BY F. Z. SCHELLENBERG.

Through Allegheny county one set of highways should conform to the general cross-cut direction that the Monongahela and Ohio rivers together take past Pittsburg, approximately straight; and the other set should be at right angles thereto.

The Allegheny river's two main courses bounding the city, showing both directions, give the first striking illustration of the coincidence in the shapes of the natural features with the geometry we have derived from them all for our far reaching procedure. In the next counties and beyond can be shown, in the whole lay of the land, the fitness of remarkably similar schemes based on the imaginary axes, so that once the Engineer's mind in recognition of these over-ruling coordinates makes the impression of their relevancy his own, the conception will be retained as a sane one if others will agree with him that the idea's beauty is in its immediate and permanent usefulness.

The projection of highway routes, then, does not require contour maps in advance, and we may be through building, in our day and generation, the first real main roads (as the greater avenues) on these proper natural directing lines, before maps of true geography are obtained, such as the enlightened states of Europe have made.

The paradox appears that we can easier project the fitting line of route—boldly direct, but feasible—where we know the

stratigraphy' than the uncertain line of good direction out of the crookedness of tentative topography, whose diversions are rectangular in the end, and that ought to be followed only as we would build cheaper rather than better. Of course, there being a study of the relation of gradients to cost of construction to look forward to while making the surveys, we must abide erosion's old ruins of cliff and ravine, and judge the degree of abruptness that may be allowed incidentally to affect the profile of gradients and the location of directions.

East of us here; there where the cross dips are stronger—if there is not also pitch on the trend to regard, with a resultant—we will have to consult a directrix derived from intended deference to gradient in the projection of the route itself and break up its straight line of direction, thus providing scope for a salient of lines to grade over the hill as contrasted with re-entering curvature over the valley between it and the next hill. The trend routes will have long courses—between the offsets that will have to be found.

And so the experimental line to explore the terrain, directed by the active, but reflective, surveyor's hand and eye—the compass box's level plane making intelligible the fall of the ground around and aiding to the choice of sight line for grade in advance of the elevation levels that will be given to stations he is about to set—will settle the hypothesis' composite of direct and winding location line.

There is from the nature of the grades allowable an easier adherence to direction here contemplated than with the

(1.) We have our knowledge of the regional stratigraphy from the State geologists reports, maps and vertical sections. Each mining engineer has the closer knowledge of particular localities from the accurate surveys made for the lawful maps, and the contributing data of the coal crop lines, etc., at the surface, united also on more general maps by him. These have been joined by sketching on the often only comprehensive maps to be had—the faulty irresponsible county maps made and made over for sale these many years—the geologist cutting them into pieces for his local basis in sketching in outcrops, aided by the barometer, where an actual survey's result is not given to him, mostly because it was never made so in the undeveloped section of the county. The state's physical geography awaits the triangulation bases of the U. S. coast survey and of the state over it, together with correct systematic spirit leveling to extend and tie the railroad data, etc. In each county, though, there might be the framework for permanent geodesy and geology, required also for correct political division and property division lines in real relation, that would be given by latitude and longitude determined at each county Court House, and a few meridians and parallels drawn throughout the county (by triangulation?) for all time to have interpolation by correct survey between.

passing of the parallel mountains by the railroad, on the fewer routes available to it to go from one deep gap to another, almost regardless of direction yielded up.

In the settled country the belt of topography finally made on map may serve with extensions of it into the areas of the common roads, to help these to proper rectification afterwards.

Modern highways that shall become the greater arteries of inter-communication between the counties and should be built by them, are the ones that should receive State aid (as the populous places are not all central in the counties), however, the plan be that may be decided upon for helping the townships to get good local roads. In general there seems to be required a co-operation of local individual and public corporate effort to earn the State subsidy.²

The heightened grade of rural living would bring in the upbuilding of small central communities of divers occupations so needed for mutual helpfulness in a neighborhood. There is to be repopulating of the interior to offset the disproportionate gathering into manufacturing towns on railroad and river.

Pennsylvania's township roads have been favored by the abrogation of the 120-year-old fence law. Under the repeal there is now required the enclosing of one's live stock instead of the former fencing everywhere against all domestic animals with their right to the open commons. So the fences are disappearing (that it was said had to be horse-high, bull-strong and pig-tight for one legally to sustain a complaint against trespass of others' animals) and along the roads the side slopes can now be tidy and the sunshine get in over them. The general use of four-horse road scrapers that open the side drains and round up the surface of the road is markedly beneficial.

It has been made lawful to maintain a sidewalk in front of one or more properties on country roads, as some one explained it, for "pedestestrians." But our scout, the bicy-

(2) There is grave doubt of the wisdom of the enlarged State appropriation to the common schools, as it appears to have much invalidated wholesome local effort.

clist, awaits the advent of widened roadways that shall have a side path for him ; he would occupy narrow ground as a transformed pedestrian, to whom the courts have allotted the rights of a vehicle. He has noticed the field farming heading its furrows for the public road as the main drain for surface water off the fields. He is sometimes accompanied by another with quicker intuition of the needs of country places on the social side, if not of the material questions to be answered before getting good roads. He is very sensitive to any uphill grade, and impatient of the entire absence of level grade on the paved streets with dips to the side and pitch along. Like the gentleman with the trotting horse, he cannot understand why some park roads cannot follow contour lines instead of all either going over a hill or dropping into a deep hollow by exquisite windings.

The Deputy Secretary of Agriculture, John Hamilton, has sent a circular letter to the Judges of the Courts of Common Pleas of the whole State and to the Societies of Engineers, calling for better road views in laying out "the highways," suggesting that the Courts procure "the services of professional engineers who will make thorough surveys and who will furnish topographical map and provide drawings of the road proposed, together with the width of streams, the height of abutments of bridges, and the length and width of bridges themselves, together with an estimate of the cuts and fills and entire cost of the work." He would have no road, except in extreme cases, over five degrees grade, and if possible not over three degrees, and the right of way thirty-three feet wide. He suggests a Road Viewers' Report in form as follows; (bracketted out and italicized in by us):

"All reports of boards of viewers appointed by this Court to view and lay out new roads in this district shall contain full and explicit information upon the following points:

"First. The date of the view? Second. When held? Third. Whether proper legal notices were given? Fourth.

What viewers were present? Fifth. Whether they were severally sworn or affirmed? Sixth. Between what points the proposed road is desired? Seventh. Is such a road necessary? Eighth. Should it be a public or a private road?

“Ninth. Submit a [plot or draft] *plan* of the proposed road giving [courses] *bearings* and *distances of courses*; also indicating where the line of the proposed road crosses other roads, property lines, streams and ravines; also showing location of buildings and other improvements near which it may pass.

“Tenth. Submit *elevation drawings*: a profile [drawing showing the elevations and depressions and contour] of the surface over which the road runs, *and cross sections, or in lieu of these make the plan into a topographical map by adding the level lines of contour.*

“Eleventh. [Draw all maps and drafts to scale.] The vertical lines of the profile [map] to be upon a larger scale than the base line.

“Twelfth. Show the [number of degrees of grade] *gradient on the profile* at various points.

“Thirteenth. Describe the character of the ground over which the proposed road runs, giving also the kind of sub-soil; whether rock, clay, gravel, sand, muck, etc.

“Fourteenth. Mark on the profile [map] the *quantities in cuts and fills with the greatest height and depth of these*; also, the height and length of all bridges and culverts.

“Fifteenth. Make out and submit an estimate of the cost of constructing the road. Sixteenth. State whether or not damages are demanded; if so, how much and by whom? Seventeenth. State whether any protests were made against the laying out of the proposed road, and if so, by whom? Eighteenth. State the objections, if any, raised against granting the road. Nineteenth. Have you laid out this road over the shortest and best practicable route. If not, why not?

“To be dated and signed by each member of the Board of Viewers present at the view, giving names in full and post-office addresses.”

Mr. Hamilton is the author of the original bill of Act No. 160 of 1897, and he says further :

“I am also anxious that we shall bring to bear upon the members of the legislature, who are to be elected from the several districts, such influence as will secure from them a pledge to support the appropriation of one million dollars for roads, so that the road law passed in 1897 can be put into effect, and also to get them to agree to support such legislation for road betterment, as may be found judicious and necessary.”

In Allegheny county the question of county aid to the township roads had, before the Flinn road law, been confined to the stream and ravine crossings, that in the estimation of viewers are too expensive for the townships—bringing in the building and care of the bridges and ostensibly of all county structures—and it was this as well as the ex-officio service as a viewer on opening and vacation of township roads that was provided for in the Act of February 24, 1873, creating the office of County Engineer, to be appointed by the Judges of Courts of Common Pleas. The Act was drawn by the late Henry Warner, a man who served the county with distinction in official capacities, and was a trusted, prominent citizen in great public emergency. The office expends about \$70,000 annually.³

The valuation of all property for assessment of taxes in Allegheny county amounts to five hundred millions of dollars; the Flinn road law tax, limited to two mills annually, has been for the two years past and this year, laid at one-half a mill on the dollar for each year.⁴

(3.) The County Engineer is to give us illustrations and plans of stone and steel bridges—the types of the new county bridges, built under his direction.

(4.) The County Road Engineer will give us plans of constructions under his direction of the new county roads. We also expect from G. L. Peck, Supt., plans of road bridges crossing railroad, built by P. C. & St. L. R. R. Co.

The physiognomy of hill and ravine varies according to the particular group of these sedimentary rock measures that is due at the general elevation of the surface of the locality; and the quality of the subsoil, which has resulted from the decay of the rocks, affects the natural roads as it does the farming operations. To the practiced eye the landscape betrays the geological phase of its parts, far away and near, on any scale.

In our coal measures we have the regular order: Coal seam topped by shale, then sandstone, while underlaid by fireclay, then limestone. The entire coal seam may be one persistently divided into distinct seams of coal by separating seams of fireclay. From a group of measures the bed of clay will be the impervious floor for percolating waters to discharge as springs at the surface, and at a coal seam's crop dipping outward will be a terrace from the action of water coming over the fireclay.

In the river bluffs about Pittsburg we have the upper half of the lower barren measures extending down over 300 feet from the Pittsburg coal seam to the Crinoidal limestone with its little coal bed, exceptionally under it. This limestone is well shown on the rock shelf, where the Panhandle R. R. runs on the South Side, and is interesting as being the latest marine formation, exhibiting in plenty crinoid—old coral—remains.

The variously colored shales we see in column of the bluffs, we may be sure, will each, as it successively outcrops beyond these hills to the north, and right and left toward an anticlinal axis, make local flat surfaces of stiff clay. The upper productive coal measures extend in thickness about 365 feet up from the Pittsburg coal seam, in a repeated series of coal and attendant larger strata of limestone under and sandstone over, to the Waynesburg coal seam, and forming almost solidly the surface of southern Allegheny county. Their limestones from the breaking down of the contained clay and iron impurity, on exposure, make heavy, bad roads, of limestone clay so called, where they are at the surface.

Over these measures come the upper barren measures, culminating with a total thickness of 1200 feet in Greene county in an upper tier of high hills. Bad roads.

But the lower barrens, first mentioned, are perhaps the worst, as there is scarcely a stratum in them whose debris will withstand the weather until made into loam at best; their hills are gashed by intermittent runs from rain and snow.

North of these rivers they form the hills wholly until in the change of elevation there appear beneath at the surface the Mahoning sandstone and the Freeport coal of the lower productive coal measures. The belt of these latter measures, that have a thickness of about 300 feet, is packed steeply inclined next the first mountains. They are held good in the variously pitching basins between the western mountains and go out with their last southeastern rise through the top of the Allegheny mountain; they spread over the country to the northeast and flattening around to the northwest. They give better natural roads, the sandstones being more in evidence.

As there are differences between the regions in the size and quality of the valued rocks and their intervals in the same series, and the axes of elevation are so variously disturbing, there is far from recurring sameness in the aspect, even were there not considerable changes in absolute elevation from which there are effects of climate, as peculiar vegetation, etc., due also to moisture of prevailing winds, and latitude, with altitude.

The equal elevation, above tide, 1,100 feet, of Pittsburgh hill tops, of Greensburg and of Johnstown (also of Altoona) seems to be about an average altitude for the rolling tableland of the coal measures between the extremes of 700 at the Ohio river here and 2,400 on the Allegheny mountains. At the north this is exceeded at the inland smaller lakes south of Lake Erie, which is 573, being 1,100 to 1,300, and showing the possibility of water resource from an immense area for the ship canal proposed, whose long summit level is to be 900—

rather lower than the near summit of Pennsylvania R. R., between the two rivers, about Wilkinsburg; the railroad's next summit between them being at Carr tunnel, 1,200.

The Allegheny River's rise is one and one-half feet per mile for thirty miles, or two feet per mile for 130 miles to Oil City.

Up the Monongahela the first 100 miles averages one foot per mile.

On the cross-cut N. W. by W. here the dips and rises of the strata, as the shortest and strongest in that direction, do not exceed two degrees; while their trend N. E. by N. averages a rise, which is long—hardly one-fourth of a degree from the horizontal.

Further east the dips from the anticlinals increase in steepness, and the pitches up and down along the trend vary more there.

It may be remarked as a criterion, that with equal elevation of the surface, the Pittsburgh coal seam here at the surface, is at the southwest corner of the state a thousand feet deep, and the Venango oil sands ranging with it 2,000 feet deeper come to the surface around the northeast, in a wide margin owing to their total thickness, showing a rise of over 3,000 feet. But nearer southeast of us, in the heart of one after another of our western mountains where the river has cleaved a gap, peep up these lowest of our Western Pennsylvania surface measures.

There the volatile hydrocarbons—gas and oil—derived from early marine animal organisms, have been dissipated owing to the steep tilting of the measures—gradually turning up the edges of the covering ones from the depths to the day. While westward here and beyond in broader waves of the rocks, sealed under slates and clay-shales, and where those sands occur coarse and pebbly and can hold the intruded fluids reservoired—in segregation by their pressure to balance the water head—the oil driller, probing half a mile, more or less,

down to them, strikes oil, gushingly if he hits into a fold of a basin's side, in his quest for the zone between the little gas standing higher and the greater water lying lower.

And ever after he fathoms for it again on a forty-five degree line or in a twenty-two and one-half degree line angling to the right from the meridian, as he conceives the pool, until the gas is tapped off and the water follows up to replace in the sand the flown gas and oil that had penned it down.

And he knows about the offsets to the left.

MEETING OF THE CHEMICAL SECTION.

PITTSBURG, PA., February 17, 1898.

The regular monthly meeting of the Chemical section of the Engineers' Society was held at the Society's rooms, 410 Penn avenue, February 17, 1898. Chairman, J. O. Handy. Secretary, A. G. McKenna. Attendance, 10.

The minutes of the last regular meeting were read and approved.

Mr. Handy stated that he had nearly completed a card index of the titles of books and journals devoted to chemistry and its applications in the Carnegie libraries of Pittsburg and Allegheny and in the library of the Pittsburg Library Association. This index will also include the more important works in the private libraries of members of the Society. It will be placed in the lower drawer of the case now used for the card-index of member's names in the Society rooms.

The resignations of Messrs. Crabtree and Mixer were announced.

Mr. J. O. Handy then read the paper of the evening on "The Municipal Laboratories of Hamburg, Germany."

The reference by Mr. Handy to the subject of water purification abroad called out a general discussion. Mr. Handy said that in the light of his Craig street filtration experiments, and of the more recent and thorough work of the experts employed by the Filtration Commission, sand filtration was sure to be successful in Pittsburg. At Louisville, Ky., the filters had been clogged by fine river silt. The suspended matter in the Allegheny river was of a different character and could be eliminated.

The corrosion of steam boilers by the action of water containing small amounts of sulphuric acid or ferrous sulphate is common along the Youghiogheny and Monongahela rivers.

In order to determine how much lime or soda ash must be added each day to the feed water it is necessary to have accurate determinations of its acidity. Mr. Camp and Mr. McKenna explained that this could only be attained by adding to a measured amount of the water five c. c. of d. n. sulphuric acid, boiling for half an hour, cooling and then titrating back with d. n. sodic hydrate solution, using phenol-phtalein indicator.

The corrosion of feed water pipes conveying hot water to boilers was discussed. Mr. Handy related an instance of trouble with a steel pipe having the composition :

Carbon.....	.09%
Manganese....	.62% to .53% in different parts.
Phosphorus...	.090%
Sulphur.....	.054%
Silicon ¹.....	.025%

It was badly pitted by the action of hot water which it conveyed from a pump to the boiler. The hot water came to the supply tank through an externally heated brass coil and a certain amount of water returned from the steam radiators of the building. A short time before the pipe became entirely perforated a quantity of tri-sodic phosphate had been put into the supply tank. Probably this compound loosened some of the rust and scale which covered the already deep corrosions. The pitting action then continued to a finish.

Pittsburg water was used. This has never been known to be acid or to carry an appreciable amount of iron salts.

Dr. Stahl and Mr. Loeffler said that they had noticed similar effects. Mr. Camp said that he had often seen the same thing in steel pipe and he thought that the trouble was generally due to uneven distribution of the manganese in the metal. Electric action was set up between different portions of the material and corrosion was the result.

The inflammability of ammonia was discussed. Dr. Stahl did not think that pure ammonia gas would either burn con-

tinuously or explode. Mr. Handy said that he had been obliged to go into that question very thoroughly and he had found that pure ammonia would burn with a flame which could carry fire from a gas jet or arc light to any inflammable material in the vicinity.

Adjourned at 10.20 P. M.

A. G. McKenna,
Secretary.

THE MUNICIPAL LABORATORIES OF HAMBURG, GERMANY.

BY JAS. OTIS HANDY,

Chief Chemist of The Pittsburg Testing Laboratory, L't'd.

To many of us, the great commercial center, Hamburg, second in trade only to New York or London, is chiefly known as the European city which because it neglected to filter its water supply, suffered severely from cholera in 1892. It has been a conspicuous object lesson for the advocates of purer water ever since. Altona, just below Hamburg, did not suffer from cholera in proportion to its population. It had comparative immunity because of its better water supply. Both cities drew from the Elbe, but as the Hamburg supply was drawn above that city and the Altona supply from below Hamburg and its sewers, the former was naturally the purer. The Altona supply was passed through sand filters. The Hamburg one was not. One water conveyed no cholera to its consumers; the other did.

All this is calculated to give one a very sombre idea of the progressiveness of Hamburg. It is, however, never too late to mend even in sanitary matters. The enlivening effect of cholera on those who survive is very great indeed. Hamburg worked day and night, and in 1893 finished and put in operation one of the finest filter plants in the world. The visitor to that city now may and does drink the water without fear. It did not stop after building filters for the water supply but revived old sanitary measures and put in effect new ones so that the city's health is now surrounded by safeguards.

There is a model disinfection station where whole cargoes of immigrants can be cleansed in a most thorough manner. Entering the building, their clothes go one way and they themselves another, only to be re-united in about ninety minutes, clean and dry. Their heavy clothing and personal effects are

sterilized by live steam. The sterilizers are steam-jacketed and are very ingenious. The clothing is hung up and the heavier things placed on a lattice floor. Doors are fastened and the articles are exposed for about twenty minutes to live steam and then for twenty minutes more in a separable continuation of the same cylinder. Here the heat of the steam-jackets aided by air circulation soon dries the articles completely.

People and their belongings are also brought here in special closed wagons from their homes, if contagious disease has come there. When allowed to depart their condition precludes them from further spreading disease.

Men are sent out from this station to disinfect dwellings. Each one is furnished with a complete outfit for his work. This outfit is wonderfully extensive. There are sponges, brushes, disinfectants, and all such things as you might think of, together with dozens of other things which you would never dream of. The man has all the necessary tools of the plumber, carpenter, paper-hanger, mason, locksmith and general utility man. Every article which he uses and even the clothing which he wears is thoroughly clean and sterile.

The station for burning refuse is an important sanitary institution. At one plant, the waste from half the 600,000 population is burned. This amounts to about 160 tons per day. The refuse is collected in covered iron wagons. After arrival at the station, the wagon bodies are lifted from the trucks by cranes and their contents dumped on the tops of the destructor furnaces. These furnaces are made by the Horsfall Co. of Leeds, Eng., and they work continuously under forced draft. They are stated to be practically odorless. They were so at the time of my visit in April, last. A small proportion of coal is fed with the refuse. The clinker amounts to 60%. It is crushed and the iron is magnetically separated, the remainder being sized and sold for road making. For the iron they receive \$0.25 per ton and for the ballast about \$0.25.

In connection with this as with nearly every other public institution in Hamburg, there are good bathing facilities, which the men not only may but must avail themselves of. They are required to wear one set of clothes at their work and another **on the street**. The bath rooms are fitted with special devices to prevent the men from turning on steam by mistake and thus acquiring burns and a prejudice against bathing.

The sewage of Hamburg is mainly discharged into the Elbe which is swift when the tide is going out, and is large at all times. Altona probably objects to this practice but without effect. Experiments are being made on the purification of the sewage from the great isolation hospital, the Allgemeine Krankenhaus. When the most satisfactory plan has been decided upon, it will perhaps be extended to the whole city.

I have reserved until last the description of those features of Hamburg's sanitary system which have most interest for men of our profession. I refer to the municipal laboratories, the old State Chemical Laboratory and the newer Hygienic Institute. I shall also speak of the Altona municipal laboratory. I had the opportunity of visiting all of these, last Spring. They are deservedly celebrated institutions, but I had not heard of them and it was by fortunate chance that I found them.

Having accidentally discovered the Altona water works, on my second day abroad, I learned from the filtermeister that the chemical and bacteriological control work was done by Herr Dr. Riensch of Altona at the municipal laboratory. Through Dr. Riensch, I met Dr. Dunbar, director of the Hygienic Institute of Hamburg. The Altona Laboratory was new and finely equipped. It occupied a number of rooms in a brick building on the grounds of the city gas works. The laboratories of the Hygienic Institute were numerous and considerably scattered. They have since been brought under one roof in a very fine building, of which I was shown the plan. Dr. Dunbar was

most courteous. He explained their organization and even detailed one of his assistants, Herr Dr. Budenburg, to accompany me to the various sanitary institutions and laboratories.

The growth of the Hamburg control laboratories has been gradual. The State Laboratory, under Dr. Denstedt, is the oldest, and it was up to 1892 practically the only place for the analysis of food and household articles. From 1880 it trained a limited number of police officers to make the simpler food control tests. Up to 1888 the number of samples annually examined was small. In 1888 even, only 121 analyses were made.

By 1889, however, certain farmers had developed the unpleasant but lucrative habit of mixing oleomargarine with butter. The honest dealers appealed for protection and increased activity in the food control resulted. In 1890 eight hundred and fifty, and in 1891, thirteen hundred samples, chiefly butter, were examined. The fraud was checked and the usefulness of the food control fully proven. In 1892 came the cholera with its interruption of everything, the food work included. The police had other work to do.

The prevailing conditions called into life a temporary sanitary organization called the Hygienic Institute. This proved so generally useful that after the epidemic had passed, it was made a permanent organization. Into its charge was given the food and water control, while the State Chemical Laboratory retained toxicological and commercial chemical control work. The pure food laws were revised and the control seems now most efficient.

For the rough work of sample taking, making preliminary tests, etc., the police officers trained at the Hygienic Institute are used. For the ultimate control work only thorough and especially trained chemists are employed.

The milk supply is most carefully guarded. The police inspectors meet the milk at the railway stations, the wharve or the city entrances. They examine samples for color, odor

taste and density and sometimes for the test of coagulation by heat. Bad milk is at once poured away. Suspicious samples are officially sealed and sent at once to storage while a sample is taken at once to the laboratory for immediate analysis.

At the laboratory, tests are made for the following constituents:—

Total solids;—10 c. c. are evaporated in a Soxhlet oven, having a glycerine jacket. The time required for complete drying is 45 minutes.

Specific gravity;—Standard lacto-densimeters reading to the fourth decimal place are used.

Fat is determined by Gerber's method. 10 c. c. of a mixture of 200 c. c. of water and 1,000 c. c. of concentrated sulphuric acid, is added to 11 c. c. of milk in a special tube with graduated neck. 1 c. c. of amyl alcohol is added, the liquids mixed and the tube after closing with a rubber stopper, is heated in a water bath at 70° C. for five minutes. The tubes are then centrifugalled. After this they are again heated in the water bath for five minutes, then cooled and the volume of the fat read off. I found this method the favorite one all over Germany and in Switzerland. It gives uniformly good results which agree with those obtained by the gravimetric method. The average difference is .05 %.

They recognize in Hamburg three grades of milk which may be sold legally for what they are:

First. Full milk. This is cow's milk to which nothing has been added and from which nothing has been taken away. It has a minimum fat content of 2.7 % and a minimum gravity of 1.029 at 15° C.

Second. Half milk, the product obtained by mixing skimmed milk with full milk or by only partially removing the cream from full milk. It must have at least 1.8 % of fat and a specific gravity of 1.030 at 15° C.

Third. Skimmed milk. This milk has usually been centrifugalled. It must have a fat content of at least 0.15 % and a specific gravity of at least 1.035 at 15° C.

In cases where both inspection and laboratory tests leave the question of milk falsification still slightly in doubt, the inspector goes to the dairy where a so-called "stallprobe" is made. By measurement and other tests he ascertains whether the cows are actually producing milk of the same quality and in the same quantity as the owner had been selling.

Milk from dairies where cows or people are sick is debarred under penalty.

The carriage of water for cooling purposes on milk wagons is only allowed if the water is first colored with aniline red to prevent accidents.

This paper will be followed by a second wherein the methods used for controlling the adulteration of other food products will be more fully described.



ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the Society's House, No. 410 Penn Avenue, Pittsburgh, Pa., at 8.15 P. M., March 15, 1898, the President, Mr. George S. Davison, being in the chair. Twenty-seven members and visitors were present.

The following gentlemen were reported as passed by the Board to be voted upon at the next meeting :

G. A. F. Ahlberg, Mechanical Engineer, for Wilson-Snyder Mfg. Co.

W. Edward Berg, Mechanical Engineer, with Jones & Laughlins, Ltd.

Wm. Parker Flint, Mechanical Engineer, with Westinghouse Machine Co.

Wilhelm Forsstrom, Mechanical Engineer, with Jones & Laughlins, Ltd.

William J. Hunker, Sup't of the Allegheny County Light Co.

David Hunter, Jr., Sup't Allegheny City Electric Power Plant.

Joseph Plummer Karch, Draughtsman with Westinghouse Machine Co.

Robert M. McKinley, Signal Engineer, with Penna. Lines West of Pittsburg.

Edward E. Erikson, Engineer and Contractor, Conestoga Building.

Percy H. Thomas, Engineer, Westinghouse Electric and Mfg. Co.

The following gentlemen were balloted and duly elected to membership :

Thos. R. Morgan, late General Manager Morgan Engineering Co., 462 Atlantic Avenue, E. E., Pittsburg, Pa.

John McDonough, Master Mechanic, Duquesne Steel Works of Carnegie Steel Co., Duquesne, Pa.

Jno. M. Phillips, Manager, Phillips Mine Supply Co., S. 23d and Mary Streets, Pittsburg, Pa.

Lewis D. Rights, Structural Draughtsman, Shiffler Bridge Co., Pittsburg, Pa.

Nelson C. Wilson, Member of firm of Wilson & Wilson, Engineers and Contractors, 1012 Carnegie Building, Pittsburg, Pa.

The Board reported a donation to the Society by Mr. Emil Swensson, consisting of two dozen forks, to be used at the lunches which are held after the meetings. The thanks of the Society were voted to Mr. Swensson.

For the Library Committee, Mr. Albree reported progress, and requested information as to whether the use of the library was to be strictly confined to members. The President replied in the affirmative, but stated that exceptions would be made.

It was suggested that a notice be published to the effect that all books which had been borrowed from the library should be returned at once.

For the House Committee, Mr. Lyons stated that bids had been received for the book cases.

Some discussion then ensued as to the advisability of appointing a committee to confer with Mr. Anderson, librarian of the Carnegie Library, with respect to the purchase of technical books, but the matter was held over for the present.

The question of binding reprints was brought up by Mr. Garrigues, and the matter was referred to the secretary.

The business of the Society for this meeting being the consideration of the New Constitution, it was voted that the

Society go into a Committee of the Whole, Mr. Lewis being named as chairman and Prof. Fessenden, as secretary. The Secretary then read the report of the previous Special Meeting of March 2, 1897.

Some discussion ensued as to the amount of the dues. The statement was made by the Chairman that when the dues had been raised on a previous occasion there had been no immediate result, but that in a short time there was a dropping off in the membership. This statement was corroborated by Mr. Swensson.

It was then voted that the word *election* be substituted for the word *membership*, in the 6th line from the bottom of page 5, Article III, Section 1.

The following was then voted to be substituted for the first sentence in Article II, Section 2: "There shall be three classes of members—active, junior, and honorary. Active members shall be entitled to vote, and to hold office. In all other respects all members shall be equally entitled to the privileges of the Society. Members under twenty-five years of age may be elected to be junior members.

It was voted in Article III, Section 3, the word *active* should be omitted before the word *membership*.

It was voted that in Article IV, Section 1, the word *junior* should be interpolated between the words *active* and *members*, and that the word *initiation* should be substituted for the word *entrance*.

It was voted that, in Article IV, Section 2, the first sentence should end after the words *per annum*; that a new sentence should commence with the word *persons*, and that the following sentence should be added: "Honorary members shall be exempt from all dues."

It was voted that in Article IV, Section 3, the first sentence should read as follows:—"The annual dues shall be payable in advance on January 1st," and that the word *annual* should be substituted for the word *December* in the same Section.

Section IV having been passed, it was moved that the Committee adjourn and report to the House. Thereupon the Committee adjourned and recommended the adoption of the above amendments and additions by the Society.

The house voted that the report of the Committee be accepted and filed.

The meeting then adjourned at 10.30 P. M.

REGINALD A. FESSENDEN,
Secretary.

MEETING OF THE CHEMICAL SECTION.

MARCH 17, 1898.

The meeting was held at the rooms of the Engineers' Society. There were present eight members and one visitor. Mr. McKenna being absent, Mr. Isaacs acted as secretary.

Prof. Phillips stated that the book of methods of analysis which the members of the section had given to the Chemical Publishing Company of Easton for publication would probably appear very shortly.

Mr. Camp reported the progress of the Society in the discussion of their proposed new constitution. One more evening would be required. Among the salient features were the increase of annual dues of resident members to \$8.00, the creation of a class of junior members at \$5.00 a year, the dropping of a member from the rolls publicly after one year's non-payment of dues. Messrs. Stahl and Garrigues believed that the new constitution should provide that the chairman of the Chemical Section should be a member of the board of direction, because he is most in touch with the interests of the section.

Mr. Handy exhibited his card index to chemical and metallurgical books.

The chairman then read a paper on Food and Water Control in Hamburg, Germany. This was discussed by Messrs. Phillips, Garrigues and others.

Adjourned at 10 P. M.

A. S. ISAACS,
Secretary, pro tem.

FOOD AND WATER CONTROL IN HAMBURG.

J. O. HANDY.

PITTSBURG, March 17, 1898.

As it is probable that the milk control in Pittsburg and Allegheny will eventually assume large proportions, the author inserts for reference an abridged copy of the Hamburg milk ordinance.

THE HAMBURG LAW REGULATING THE MILK TRAFFIC.

APRIL 18, 1894.

1. Three forms of fresh cow's milk may be sold:

Whole milk, which is cow's milk to which nothing has been added and from which nothing has been removed. It must contain at least 2.7% of fat and have a specific gravity of at least 1.029 at $+15^{\circ}$ C.

Half milk, which is cow's milk, containing less fat because of partial removal of the cream, or because of its preparation by mixing together whole milk and skimmed milk. It must contain at least 1.8% of fat and have a gravity of at least 1.030 at $+15^{\circ}$ C.

Skimmed milk, which is cow's milk which has lost nearly all of its fat by centrifugal separation. It must contain at least 0.15% of fat and have a gravity of at least 1.035 at $+15^{\circ}$ C.

2. Milk cannot be sold if it is blue, red or yellow, bitter, salt, sour, slimy, stringy, malodorous or bloody. It must not come from injured or diseased cows. It must be free from added water or preservative substances. After the birth of a calf, milk must not be sold until it no longer coagulates on boiling.

3. Milk intended for sale and all vessels which come in contact with it are to be handled with the greatest care. The milk must be kept only in rooms which are dry, light and well aired. It must never be kept in lodging rooms.

4. The advent of contagious disease in the home or place of business of the milk dealer must be made known within 12 hours to the sanitary officers. No employe, who comes in contact with contagious disease, can be allowed to have the handling of the milk. Wherever it is not possible to remove the source of contagion, the police are given authority to close the dairy for the time.

5. Vessels for transporting milk may be made of wood, tin, stoneware, porcelain or glass. The wooden vessels may be painted if the pigment used is not poisonous. Tin used for cans must have less than 1% of lead and the solder used for the joints must not contain more than 10% of lead. This applies also to all tinned utensils used for handling the milk at the dairy. Stoneware with imperfect or poisonous glaze must not be used, nor may vessels of copper, brass or zinc be used for holding or conveying milk. All utensils must be cleansed with boiling water. To facilitate cleansing, the vessels should have large openings.

6. The vessels used for carrying milk must have closely fitting covers, and in the case of cans, the covers are to be chained on. The utensils must be used for no other purpose than milk transportation. If other articles are carried on milk wagons, they must be carefully excluded from contact with the milk cans.

7. Cans must be clearly marked to show the kind of milk which they are supposed to contain. If the wagon is closed, this sign must appear on the outside.

8. Water must not be carried on milk delivery wagons except a moderate amount colored for safety with a red dye stuff. This water is to serve only for surface cooling in summer or warming in winter.

9. Persons desiring to sell milk must notify the police bureau.

10. The police are given control of the milk traffic and have all authority required for search, seizure, arrest, etc.

11. The owner of cows must see that the most scrupulous cleanliness is enforced. The udders of the cows in the hands of the milkers must be washed. The first streams of milk are to be rejected. The state veterinary supervises the sanitary arrangement of dairies. All cases of sickness must be reported to him and he prescribes the treatment and debars the use of the milk as long as necessary.

12. Penalties for violation of this law are a fine up to 150 marks or imprisonment for a period not exceeding six weeks.

For the proper enforcement of this law, the Hygienic Institute and the Police Department cooperate. Police officials are trained for the preliminary work of inspection at the Institute. The chemists at the Institute make the final control analyses.

DUTIES OF MILK INSPECTORS.

Each man is furnished with the following outfit :

1. A lactometer with which is combined a thermometer. They are of the form suggested by Quevenne and give accurate readings to the third decimal place. All readings of specific gravity are corrected to 15° C. by tables. The instruments are periodically standardized at the Institute.

2. A 200 c. c. measuring cylinder.

3. A leather satchel in which to carry the above apparatus and also four $\frac{1}{4}$ liter test bottles of half white glass, a spoon for stirring and a cloth for cleaning the apparatus after use. The bottles bear labels.

4. Test-tubes for the boiling test.

The inspectors meet the milk at the railway stations, the steamboat landings or at other points of entry and carry out the following preliminary control tests: The sample to be examined is first thoroughly mixed by pouring or stirring. The measuring cylinder is then filled to the mark and the following observations are made: color, taste, odor, viscosity and general appearance. If any of these cause suspicion, the containing vessel is at once sealed and sent to storage while

sample is sent to the Institute laboratory for final tests. If the first test causes no suspicion the gravity of the milk is carefully taken with the lactometer, bearing in mind that the density of milk does not reach its maximum until at least three hours after milking. If the gravity is not right, the sample is set aside as before. The inspectors have only the power of setting aside all milk which does not come up to their tests. The final decision as to the disposition of the material comes from the Hygienic Institute where the following tests are made of the inspector's milk samples:

FINAL CONTROL TESTS.

1. The inspector's observations of appearance, taste, etc., are checked up.

2. The reaction of the sample is observed by means of litmus paper.

3. The density of the milk is taken by means of very accurate lactometers reading to the fourth decimal place. They are frequently standardized and must be used only between 13° and 17° C. Correct to 15° C.

4. Fat is determined by Gerber's centrifugal method. 10 c. c. of 83% sulphuric acid, 11 c. c. of milk and 1 c. c. of amyl alcohol are mixed together in a small rubber stoppered bottle and heated for five minutes in a water bath at 70° C. The bottles are then revolved for three minutes in the centrifugal, a light running machine made by F. Hegershoff, Leipsic. After this they are removed and again heated for five minutes to 70° C. They are finally cooled and the amount of fat read off. This method was only adopted after careful comparisons with other accepted methods had established its accuracy.

If the sample is suspected after the above tests, the following additional ones are made:

5. The fat is redetermined by Soxhlet's method.

6. The dry residue or milk solids are determined as follows: A flat covered nickel dish is balanced on the scales and

10 c. c. of the milk are delivered therein by means of a pipette. The whole is quickly weighed, the cover set aside and the dish placed in a Soxhlet drying oven. This is a low walled oven of copper. The jacket is filled with glycerine. By this means a temperature of 104° C. is maintained and the sample is dry in 45 minutes, whereas the old method of evaporation took three-quarters of an hour. The fat-free solids are estimated by deducting the fat already determined.

In those cases where the fat-free solids amount to less than 8.5% the following tests are made:

7. The specific gravity of the milk serum obtained by spontaneous coagulation.

About 100 c. c. of the milk are kept in a loosely corked flask until coagulation occurs and then filtered. The gravity of the serum is determined by means of the Westphal balance or an exact araömeter.

Microscopic examination of milk is made when either of the following conditions are noted:

- (a). The milk is colored.
- (b). Sediment is present.
- (c). The milk has an abnormally high gravity and fat content.

Preservatives are tested for whenever suspected. The ones in general use are sodium bicarbonate, borax or boric acid and salicylic acid. They are chiefly used in summer.

Examinations are periodically made of tinned vessels and their soldered joints to see if excessive amounts of lead are being used.

The water used for cooling, etc., is tested for poisonous coloring matter.

In cases where the composition of suspected milk is only slightly below the standard, dairy tests must be made to settle whether fraud is actually being practised.

An inspector goes to the dairy and sees the milking done

takes all samples necessary for the final settlement of the affair and carries them to the Hygienic Institute for analysis.

HAMBURG MILK STANDARDS.

Normal full milk contains at least 2.7% of fat.

Watered milk is indicated by a specific gravity of less than 1.029 at 15° C. and the presence of less than 8% of fat-free milk solids. If the serum has a gravity less than 1.026 at 15° C., it is further evidence of watering.

Removal of cream is considered as proven if the dairy test shows over .4% more fat than the first analysis. Watering is established if the fat-free solids in the sample from the dairy test are over 0.7% higher than in the first sample.

Effect of the law on the quality of milk furnished:

EFFECT OF LAW ON THE QUALITY OF MILK.

The effect of the enforcement of the law in Hamburg was most satisfactory. Comparing the results in the years 1894, 1895 and 1896, we find that while 26% of the samples tested in 1894 were defective, only 17% were rejected in the succeeding years. About 2,500 samples were analyzed yearly. The removal of cream was practiced in about twice as many cases as was the addition of water.

One milk dealer was prosecuted for the addition of a harmful yellow coloring matter to mask cream removal.

Freezing was found to cause separation of milk into parts of different composition. If some was removed while the contents of a can were partly frozen, milk of abnormal gravity and fat content would be obtained.

The bitterness of certain samples of milk was found to be due to the products of growth of certain species of bacteria.

BUTTER CONTROL TESTS.

Samples were taken by inspectors by means of cylindrical samplers. The portions removed were kept in glass stoppered bottles. The laboratory tests:

1. The refractive index of the fat is determined by

means of a Zeiss refractometer. This is only for preliminary work. If the fat varies much from 53.5° refraction at 25° C. or 44.5 at 40 C. it is rejected. If it varies slightly but still enough to be an object of suspicion, it is tested further by the Reichert test.

2. The Reichert-Meissl test is carried out with 5 gm of fat.

3. The Koertstorfer test is sometimes made.

4. Water is determined in all suspected samples.

Owing to the early and energetic work on the butter control in Hamburg, the substitution of oleomargarine for butter is not common. The chief fraud now practiced there is the sale of butter containing an excessive amount of water. Good dairy butter was found to normally contain about 16% of water, while butter which had been reclaimed by working over with warm water contained from 16 to 30%.

CHEESE CONTROL.

In the cheese control the same precautions were observed as in the butter control in regard to the sampling and the preservation of samples. The tests used were:

1. The refractometer number of the fat.

2. The Reichert-Meissl test of the fat.

3. The saponificatio or Koertstorfer number of the fat

The principal form of fraud was the use of oleomargarine to replace the fat which cream cheese would normally contain

LARD CONTROL.

Many samples of American lards are found to be "compound." The tests applied are the same as are used in this country for the detection of adulteration. They are:

1. Refractometer number.

2. Iodine number of the fat and of the fat acids.

3. Rise of temperature with sulphuric acid.

4. Reaction according to Bechi-Hehner.

5. Reaction with nitric acid of 1.4 sp. gr.

OLIVE OIL CONTROL.

Twenty of seventy samples examined were found to be adulterated. In addition to the tests used for lard control, they use the elaidin test and also tests suggested by Baudonin and by Renard.

MEAL, STARCH AND SAGO CONTROL.

Only 13 out of 204 samples were rejected. Four samples of tapioca contained potato starch. Six samples of meal were infected with mites. Adulteration not common.

BREAD CONTROL.

Research in this line revealed very little fraud. A mineral oil of .90 sp. gr. was used to give a certain desired appearance to the crust. It was believed to be injurious, and its use was forbidden.

COCOA AND CHOCOLATE CONTROL.

Nine samples out of 133 were adulterated. In 8 of these cases the adulterant was starch, not acknowledged.

COFFEE CONTROL.

Only a small number of the samples of coffee examined were found to be adulterated. The ground coffees were mixed with grain surrogates. The roasted coffee beans were in a few cases colored by iron oxide or glazed with sugar, etc.

TEA CONTROL.

Eighty-seven samples were examined. Only three were objectionable. These had been colored with Prussian Blue.

WINE CONTROL.

Of 413 samples 82 were condemned. The reasons for rejection were:

1. An "extract" content of less than 1.5 gm. per 100 c. c.
2. Addition of alcohol and coal-tar colors to red wine.
3. Presence of salicylic acid.

4. Presence of sulphurous acid in quantities of 217 to 673 m. g. per liter.

In the analyses 12 determinations were made.

BEER CONTROL.

Eighteen of 165 samples were condemned chiefly for salicylic acid content.

It is popularly supposed in America that more care is taken to guard the purity of the beer supply in Germany than is exercised in caring for the water supply. This impression is soon corrected when it is considered that the sanitary authorities in Hamburg only analyzed 165 samples of beer during three years while they were analyzing water at the rate of 60 samples a day.

WATER CONTROL IN HAMBURG.

The director of the water works is responsible first to the Imperial Government at Berlin for the quality of water furnished. The government of Hamburg has adopted an additional safeguard by giving to the Hygienic Institute a secondary supervision of the city water supply.

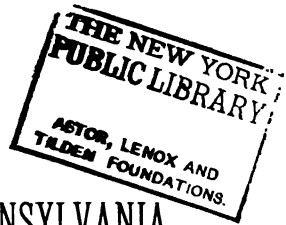
As a result there are two laboratories at the sand-filtration plant, making in all some sixty bacteriological and a few chemical tests every day. There are eighteen filter-beds to watch and daily tests are made of both raw and filtered water at various points at the works and in the city. The efficiency of filtration is already very great, and under this close supervision it is constantly improving.

The methods used for the bacteriological control are like those used here. The nutrient medium is a meat-extract, peptone and salt preparation jellified by means of 10% of gelatine and made to have when finished an alkalinity equal to $\frac{1}{10}$ % of free carbonate of soda. The cultures are made in Petri dishes at 20° C.

Analyses made at the time of my visit showed the following results at Hamburg and at Altona:

	Hamburg, April 15, '97.	Altona, April 20, '97.
Bacteria, { Raw water...	500	60,000
per cubic { Settled .....	.....	3,500
centimeter { Filtered	6 to 28	8 to 24

This comparison shows how much inferior the Elbe water at Altona is to the same water at Hamburg, and yet with a comparatively antiquated filtering plant, Altona is furnishing an unexceptionable water to its citizens. Hamburg is also doing fine work, but with much better facilities.



ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania, was held in the Lecture Room of the Society's House, No. 410 Penn Avenue, Pittsburg, Pa., Tuesday evening, April 19, 1898.

The meeting was called to order at 8.05 P. M. by the president, Mr. George S. Davison. Thirty-five members and visitors were present.

The minutes of the preceding meeting were read and approved.

The following gentlemen:

G. A. F. Ahlberg, Mechanical Engineer, for Wilson-Snyder Mfg. Co.

W. Edward Berg, Mechanical Engineer, with Jones & Laughlins, Ltd.

Wm. Parker Flint, Mechanical Engineer, with Westinghouse Machine Co.

Wilhelm Forsstrom, Mechanical Engineer, with Jones & Laughlins, Ltd.

William J. Hunker, Sup't of the Allegheny County Light Co.

David Hunter, Jr., Sup't Allegheny City Electric Power Plant.

Joseph Plummer Karch, Draughtsman, with Westinghouse Machine Co.

Robert M. McKinley, Signal Engineer, with Penna. Lines West of Pittsburg.

Edward E. Erikson, Engineer and Contractor, Conestoga Building.

Percy H. Thomas, Engineer, Westinghouse Electric and Mfg. Co.

were then balloted for and declared elected.

It was moved that the consideration of the New Constitution be postponed until after the reading of the paper for the evening.

For the house committee Mr. Lyons reported that a bid of \$59.00 had been received for two book cases.

For the Reception Committee, the President reported that, owing to a misunderstanding, there would be no lunch after the meeting. The Chairman of the Committee expected to attend to the lunch in person, but was unavoidably detained out of the city.

The paper of the evening, "A Brief History of the Advance and Use of Explosives," was then read by Mr. Arthur Kirk.

A BRIEF HISTORY OF THE ADVANCE AND USE OF EXPLOSIVES.

BY ARTHUR KIRK.

Explosives, as now used, are of far more importance to the comforts of civilized life than most persons have any knowledge of. Without explosives, we could not make iron or steel; or a single piece of glass; or build a substantial building of any kind; or a railroad or canal. And without powder, all our finely-drawn theories about coast defenses, military organizations, drills, and equipments would be pure nonsense.

Let the reader stop a moment and try to imagine a state of society *without explosives* to get out coal, iron ore, limestone, building stone, fire clay, spar (with which to make Queensware). Gold and silver mines and railroads would be unknown.

This, of course, would carry with it the total annihilation of all iron and steel tools and machines; our saws, hatchets and axes would at once disappear, and we would step away back to the stone age. There could be no substantial building erected without powder to blast stone for the founda-

tion, and the greater part of all red or fire brick is now made from blasted material. None of our fine block stone pavements could be gotten out without blasting explosives. Blasting has to be used to open the quarries, where our fine stone trimmings for brick fronts are obtained.

True, the ancient Egyptians appear to have gotten out and handled large blocks of stone without explosives; but it is now a lost art, for which great search has been made without success.

There could also not be any nice baskets of provisions with their fine assortments of pies, cakes, or cookies to accompany us for even *one* day off to the woods; for, without blasting, there could be no iron cooking stoves or ranges on which to cook these good things, nor any extra fine roller process flour out of which to make them; but the best grinding or cooking that could be had would be two women grinding at the mill, then mixing the flour with water, and without bolting or salting it, working into cakes and baking it on the coals, fresh for every meal. And our fair ladies could not have a nice new dress with latest patterned towers of fancy colored trimmings on it, just made for the occasion, for, without blasting, there could be no iron or steel to make the carding spinning, or weaving machinery to make the fancy dress goods; nor a pair of scissors to cut them; nor a needle with which to sew them, and with not even a pin to hold them in position.

In short, without the blasting of minerals, we should have to abandon all that steam engines now help to produce. All our comfortable home furniture—kitchen, bedroom, and parlor sets. Carpets would be unknown, and we should step at once into the simple style of living, practically as Adam and Eve did when they first started housekeeping, outside the gate of the Garden of Eden.

Having thus called your attention to the great importance of explosives, I ask your attention to their history.

As far as I can discover, Confucius, the celebrated Chinese philosopher, made a black powder of very inferior quality; and, although the Chinese, for an unknown long time, have used great quantities of this inferior powder in fire crackers, yet they have never made powder suitable for military purposes.

In conversation with a very intelligent Japanese, I asked him why the Chinese and Japanese had made so little progress in the arts and sciences during the last two thousand years, while other nations had made such great improvements.

His reply was: "After much study of that question, I have concluded it is because there are no patent laws in those countries."

Whether this is the true cause or not, one fact is certain: the countries most celebrated for civilization, have been most prolific in producing the means of extermination of life.

The early history of explosives is a great mystery. Very little is known of it before 1702, when a certain De La Hire is said to be the first writer on explosives. In 1743, a paper on the subject of Powder was read before the Royal Society of London. In 1778, a Dr. Hutton, of New Castle on Tyne, read a paper, in which he demonstrated that the pressure of exploded powder was 2,000 atmospheres. After that time, repeated papers were read before the Royal Society of England, many of which differed very widely in their estimates of its pressure.

But all that was said or done about improving explosives did little good until, between the years of 1857 and 1859, Major Rodman made an extensive series of experiments on gunpowder for the United States Government, and from that date starts a new era in explosives.

Previous to that time, what is now known as Common Black Powder was the only generally known explosive for stone blasting or military use, but now we have eight distinct classes of explosives, and each of these classes is susceptible to indefinite subdivisions.

Gunpowder (ordinarily so-called), is composed of

75	parts saltpetre,
12.5	“ charcoal,
12.5	“ sulphur,
<hr/>	
100	parts.

Different manufacturers, of course, vary these proportions slightly with scarcely a perceptible advantage. As this paper is merely intended to treat very briefly of explosives in a very general way, I cannot give as many details as I wish I could. To attempt to describe, even in a very brief manner, all the different patents for explosives would be far too much for this occasion.

For instance, I find by patent reports that between 1868 and 1883—15 years—there were 176 patents issued for new explosives, and no person knows how many strictly secret processes are now in use. Previous to 1868, there was not a single book in existence which was devoted to explosives, but since that time, a large book case would be required to hold one copy of all the printed matter relating to explosives. I may here mention those with which I am acquainted. First in practicability, I may mention :

“Tri-Nitro Glycerin,” by Geo. M. Mowbray ;

“Lectures on Explosives,” by Willoughby Walke, 1st Lieutenant U. S. Artillery ;

“The Manufacture of Explosives,” by Oscar Guttman, in two volumes ;

“Modern High Explosives,” by Manuel Eissler ;

“Fired Gunpowder,” by Captain Nobel and F. A. Abel ;

“Nitro Explosives,” by P. G. Sanford.

Also a large and exhaustive “Dictionnaire des Poudres and Explosives,” in French, by P. F. Chalon.

Another “Dictionnaire of Explosives,” by J. P. Cundill, British Artillery.

In 1875, the British Government passed what is known

as the "Explosive Act," under which all matters relating to explosives are governed by law. All locating of manufactories of explosives, transportation, storage, and use of explosives, are regulated by law, which is very rigidly enforced by Col. V. D. Majendie, H. M., Inspector of Explosives. That explosive act authorizes an Inspector of Explosives, and makes it his duty to inspect a sample of every new proposed explosive before it can be transported by any conveyance; and also makes it the duty of Inspector of Explosives, or his deputy, to visit the scene of any destructive accident due to explosives; to investigate and publish all the causes of the explosion, and publish the same as soon as possible, at public expense. Each report costs from one penny to one shilling in proportion to its size. These reports have had a wonderful effect in greatly reducing casualties by explosives to one-fourth of what they were before the enactment of the Explosive Act, although the quantity of explosives consumed is now four times as much as before its enactment.

This British Explosive Act empowers the Inspector of Explosives to grant or refuse permits to locate Danger Building and prescribe rules for working people; gives him authority to appoint a constable to enter works at irregular times and see that the rules are enforced; and also authorizes him to prescribe what kind of packages must be used in transporting explosives. All these rules make the manufacture of explosives far safer for every person connected with the making and handling of them. The report by the Inspector of Explosives of an accident, is generally printed and open to the public within two weeks after the explosion has taken place. As these reports are generally made out by a person who for years has made a business of inquiring into causes of explosions, they are very reliable; and are often more correct than the owner of the works, or user could have made, and hence teaches every reader to avoid the cause of an explosion without its cost.

AS TO USING EXPLOSIVES.

There has practically been no improvement or change within the last forty years in America as to blasting coal, because our mines are near the surface, yet there has been great experimenting with flameless explosives, and other novelties in Great Britain and other mining countries, of which I have not the details at hand. Within my own knowledge, however, great improvements have been made in blasting stone, clay, and stumps of trees, and salamanders, or large castings. This has largely been brought about by the use of steam rock drills to drill holes, and the employment of dynamite for blasting, electricity for firing charges, and the use of steam scoop shovels and other kindred helps. Excavations on land or under water can now be done for an average of one-fourth of what the same work would have cost forty years ago.

ROCK DRILLS.

Rock drills are of very great importance not only in cheapening the cost but also in the making of much better holes than can be made by hand. A machine-made hole is made by the automatic rotation of one revolution every seven blows, always resulting in a perfect circle. This perfect circle presents a uniform resistance until the explosive gases of black powder are fully developed. A hand-made hole from its pulsating rotation is always triangular, and thus the force of explosion along the walls of the triangles, is exerted in diverging directions, producing a rupture at the point of contact before the full force of a black powder explosion is developed. Of course, the force escapes through those ruptures before it is fully developed, whereas, in a machine-made hole, which is perfectly round, it is held in until its full force is fully developed. It should here be remembered that black powder, strictly speaking, does not explode, it is merely a very quick burner. This fact is no doubt well known to sportsmen here. After purchasing a new gun, it is customary to charge it with

a moderate charge, and fire it over white sheets, or new fallen snow, and then look for grains of powder on the white surface. The charge is gradually increased and the firing repeated until grains of unburned powder are found on the white surface. That determines the charge of powder which the gun can burn, because the finding of unburned powder upon the above-described white surface shows that it was forced from the barrel of the gun before it had time to burn.

By way of contrast, permit me to show what very recent improvements in explosives and their improved uses have done and are doing in Pittsburg to-day: When I commenced selling explosives in 1866, black blasting powder was the only known explosive in use, and it was then selling at \$6.50 per keg of 25 lbs. This very high price soon called in lively competition, and for a few years explosives were sold to customers below cost. This led to greatly increased consumption of explosives. Customers, finding that heavy shots pay better than light ones, now generally make as large shots as the surroundings will permit. During last November one shot was fired near Lilly station, Pa., on the Pennsylvania Railroad, which consumed:

1,200 lbs. of strongest dynamite,
13,750 " " Black Powder,

all intermixed, which gave good satisfaction. This cheapening of explosives has produced such a reduction in cost of making steel, that by this cause alone are the furnaces around Pittsburg enabled to compete with cheap run southern furnaces.

In 1866, the furnaces of Pittsburg received from Blair Co., Pa., 10 cars of limestone per day, limited to 10 ton per car. That limestone was sledged down to man-lift size, and cost \$1.25 per ton.

Now Pittsburg furnaces receive a daily average of 200 cars of limestone per day each containing 25 tons, or 5,000 tons of limestone per day. This makes annually 1,825,000 tons which now, by the cheapening of explosives and improved

quarrying appliances, cost only 25c per ton, thus saving \$1,825,000.00 to the furnaces of Pittsburg every year. I need not remind you that without this great saving, every furnace in Pittsburg would be cold to-day.

And this is only the beginning of what explosives can do for Pittsburg. By the judicious use, we can cheapen the improvement of our rivers and make the Pittsburg & Erie Canal with as great a saving in that line as I have shown in limestone. Besides all this, another large field is opening for explosives in removing tree stumps and rocks from farm land. I lately saw it used to very good advantage in removing locust stumps from a piece of land that had so many locust stumps in it that it was utterly useless for agricultural purposes. At a very moderate expense, this land can very shortly be worked like an old field; and what was very strange, although the ground was closely planted with fruit trees, one year old, and the fragments of stumps after each blast flew thick, yet not a twig of a fruit tree was injured.

Every reader of this will remember that 15 to 20 years ago great alarm was felt for fear of incendiary use of dynamite; now we seldom hear a complaint about it. This, I think, has come about by two causes: The damage done by an explosion of dynamite is of a local character. For instance, great alarm was caused ten years ago by an attempt to blow up the House of Lords in London, but it only made a hole in the floor about three feet in diameter.

Another cause is that it leaves a trace behind an explosion by means of which the perpetrator of a crime, by use of dynamite, has almost always been discovered and punished. For instance, dynamite is now put up in strong paper tubes $1\frac{1}{4}$ inches in diameter by 8 inches long,—this is called a stick of dynamite. Every honest manufacturer now has his address printed on his stick of dynamite. A bomb was found near Greensburg, Pa., unexploded, which had been intended to kill a superintendent of the work. On dissecting the bomb,

a small piece of the address of the manufacturer of dynamite was found. The maker of dynamite was applied to, but he had not sold any dynamite in that neighborhood for a long time; but after a long search, it was discovered that two miners had recently moved in from a place fifty miles away, where that brand had been sold, and this led to the discovery of the placer of the bomb.

It can thus be seen that the region of Pittsburg has been greatly benefited by the modern improvements in explosives.

DISCUSSION.

MR. DIESCHER—I would like to ask Mr. Kirk as to the cause of the great explosion which took place, I think, in 1894.

MR. KIRK—That was a very extraordinary case. It appears from what I can learn that it was the result of absolute, unquestionably, inexcusable negligence on the part of the proprietor. He had allowed a wooden tank, an *unlined* wooden tank, to stand for two or three years, and the lumber in that tank had become thoroughly saturated with nitroglycerine. This tank was exposed to the rays of the morning sun, and it was in the morning that the explosion took place,—about 9 o'clock in the morning. The first thing that was noticed was a blue flame rising from the tank, and then this explosion took place.

MR. DIESCHER—How about the second explosion which took place about six months later?

MR. KIRK—It takes a great deal of experience to make some men wise. I do not know. (Laughter.)

MR. JOHNSON—I do not think the paper made any reference to smokeless powders. If it did, I lost it. I would like to ask Mr. Kirk what the ingredients of smokeless powder are?

MR. KIRK—As to smokeless powder, there are so many secret processes and formulas used in its manufacture, that one can hardly tell what it is. When I was in Sweden, I was urged to take charge of a secret process, and in this process

one of the chief ingredients was molasses. It was, I believe, a strictly chemical compound. Black powder is not a chemical compound, but is a mixture. I think that all smokeless powders are chemical compounds.

MR. HIRSCH—Reference was made by the reader of the paper to a charge of several thousand pounds which had been exploded. Can you tell me what it was used for?

MR. KIRK—It was used by the Pennsylvania Company in the operations of straightening the road near Lilly's station. Holes were made in the ground about twenty-five feet deep.

PRESIDENT—Does the employment of black powder and dynamite have the same effect upon the rock left in the quarry after blasting?

MR. KIRK—Dynamite invariably makes eight cracks or fractures, radiating from the hole of the blast, about as direct as the spokes of a wheel; but black powder only makes three cracks. Hence, in quarries which are worked for dimension stone, they use black powder; and in lime-stone quarries, and in excavations where the idea is to get the material broken up as much as possible, they use dynamite. In many instances, a combination of the two seems to be best.

Mr. Kirk here drew a diagram on the board, illustrating the probable cause and effect in the Maine explosion, stating that the results of that explosion showed that at least fifteen to twenty-five tons of dynamite had been employed.

MR. DIESCHER—Is not gun cotton stronger than dynamite.

MR. KIRK—Yes, sir.

MR. DIESCHER—How much more powerful is it?

MR. KIRK—I think fifteen tons of gun cotton will produce about the same effect as twenty tons of dynamite, and certainly no private individual could have put such a large amount of explosive material under the Maine without the knowledge of the officers, whose duty it is to guard the harbor of Havana.

MR. LYONS—I would like to ask Mr. Kirk in what direction the greatest force is exerted by an explosion of dynamite. I think there is a general impression that it is exerted most powerfully downward, rather than in any other direction.

MR. KIRK—Its action is that quick that I could never tell. (Laughter.) It used to be a very ticklish operation to handle dynamite, so much so that when we went to our work, we got as far from the charge before it was exploded, as we possibly could; but now, to those who understand the business, they say it is just as safe as driving a mule, but then you must be on friendly terms even with the mule. (Laughter.) Formerly, dynamite was much more easily exploded than it is now. The man in charge of one of our works left the building to go away about 500 feet to fix a pipe that was leaking, and when he came back there was nothing there. The tank had been exposed to the rays of the sun, which probably produced the explosion. We now mix the dynamite with nitrate of soda, and in the stick form, as it is now prepared, many people consider it as harmless to handle as so much wood. I remember going out to use it on the Panhandle Road. The quarry was about 50 feet deep, down straight as a wall to where the men were working. I told them I was going to throw down the dynamite, and it did not take them a second to get out of the way. In throwing the dynamite down, some of the cartridges were broken, but I picked them up and they did excellent execution. In the shape it is put up now, it is a very safe article to handle and there is very little danger of accidental explosion.

PROF. FESSENDEN—I have been figuring a little upon the energy developed in one charge of one of our large modern guns. The striking power of its energy as I have estimated it would be equal to a 150 ton train running at 60 miles an hour, all concentrated on twelve inches of iron.

E. A. HUNT—Regarding the relative merits of the different forms of explosives used in rendering rock without frac-

turing, would say that I have had considerable experience along this line in the quarrying of marble in Tennessee. We found a considerable difference between the various explosives. I think the general rule is that the quicker the burning the greater the force of the explosive and the character of the explosive must be varied with the character of the rock to be blasted and the purpose for which the blasted material is to be used.

A question has been asked about smokeless powders. I think they consist largely of picrates—the picrate of soda or potash.

Some people imagine that, to people who understand the business, nitro-glycerine is as easy to handle and work as butter. Some people have had that idea, who, perhaps, do not have it now. But if, in its manufacture, after the materials are thoroughly mixed, if it is freed from all superfluous acid, I do not think there remains any liability to spontaneous combustion—spontaneous explosion.

PROF. FESSENDEN—The composition of smokeless powder has been brought up. I think the majority of smokeless powders are composed of mixtures of gun cotton and nitro-glycerine. Cordite is a solution of gun cotton in nitro-glycerine, with a little vaseline added so as to give enough smoke to lubricate the barrel of the gun and so prevent it from clogging up. I would like to ask Mr. Kirk or Mr. Hunt if it is true that under certain conditions dynamite sweats. Does the nitro-glycerine actually separate from the infusorial earth, or whatever substance is used? For instance, after freezing.

MR. KIRK—Dynamite freezes at 42 degrees. If kept at that temperature it will freeze, and when brought into a warmer atmosphere it will sweat, in the same manner as a pitcher of ice water. That is, it will become covered with moisture on the outside, which has been abstracted from the atmosphere; and that is the only sweating that takes place in dynamite. I have known dynamite cartridges five years old

to do as good execution as those more recently made. Time does not seem to separate the nitro-glycerine from the substances with which it is combined.

MR. HUNT—The addition of nitrate of soda tends to make the mixture a more stable one, not affected by the atmosphere.

MR. CAMP—If the percentage of nitro-glycerine is increased above a certain amount, beyond the absorptive power of the infusorial earth, has not the mixture, upon being warmed, a tendency to sweat? That is, upon becoming warmer, does not the excessive amount of glycerine tend to ooze out? Not to sweat exactly, but to actually melt out; to exude.

MR. HUNT—I think you can melt it out, but I don't want to try it, I am not in that business. (Laughter) But it can be done. Any amount above 70 per cent. or about 70 per cent. can be melted out.

MR. KIRK—75 per cent. seems to be as high a percentage of glycerine that can be permanently absorbed. As a matter of fact, however, there is not one package in 20 of the dynamite on the market to-day that contains 75 per cent. About 40 to 60 per cent. is about as powerful as anybody wants, and then it is perfectly safe.

MR. CAMP—Regarding the question of the direction of the greatest force in an explosion of dynamite, or nitro-glycerine, I would say that the hole it makes in the ground is visible, but the hole it makes in the atmosphere is not visible, (laughter) and hence the general impression is that the greatest force is exerted downwards.

MR. BOLE—I would like to ask Mr. Kirk how a charge of dynamite is generally exploded, and also the most important use of smokeless powders, and if they are actually smokeless.

MR. KIRK—Black powder is exploded by a flame, but dynamite can only be exploded by a spark. You can take a piece of powder, lay it on an iron sieve and heat the sieve

until it becomes red hot. It needs a flame to explode it. There is a general impression that dynamite is exploded by concussion. It is not. It is exploded by a spark. It is almost invariably exploded by a cap which is fully $1\frac{1}{4}$ inches long and probably a little over $\frac{1}{4}$ of an inch in diameter, and about half filled with fulminating mercury, and electric wires are run into this cap connected by a small bridge of platinum wire.

MR. DAVISON—Mr. Bole also asked some questions about smokeless powder.

MR. KIRK—There certainly must be a number of great advantages resulting from the use of smokeless powders in military operations, and these powders are practically smokeless. In the use of smokeless powders, the view is not impaired by the vast clouds of smoke which result from the use of black powder.

MR. BOLE—Does smokeless powder give a flame?

MR. KIRK—No, sir, no flame. Dynamite does not give a flame.

MR. CROKER—Does not smokeless powder burn with a bright flame?

MR. KIRK—If you give it plenty of air, but not if it is exploded under pressure.

MR. LEWIS—One of the consequences of the use of smokeless powder in military affairs, is to entirely prevent strategic movements under cover of smoke. If Captain Hunt used smokeless powder in his batteries, his every movement could be seen by the opposing forces, rendering his command liable to total annihilation. The use of smokeless powder will prevent infantry manœuvring on the old lines, and will also compel a change in cavalry tactics. It will modify operations on the sea, as well as on land. With the use of high power smokeless powder the initial muzzle velocity of the projectile is greater than it is with ordinary black powder, and hence a much flatter trajectory for the projectile with consequent greater accuracy of aim and an increased radius of destructive fire.

BUSINESS MEETING.

At the close of discussion the Society went into a Committee of the Whole to consider the New Constitution. The President appointed Mr. Bole, Chairman of the Committee of the Whole.

Upon vote, a further consideration of Section 1, Article V., was postponed.

Upon vote, a consideration of Section 2, Article V., was postponed.

Upon vote, consideration of Section 3, Article V., was postponed.

Upon vote, consideration of Section 4, Article V., was postponed.

Section 5, Article V.,

Section 6, Article V.,

Section 7, Article V.,

Section 8, Article V., and

Sections 1, 2 and 3 of Article VI. were adopted as read.

Section 4 of Article VI. was adopted as read, except that it was passed as Section 5.

Section 5 was adopted as read, except that it was passed as Section 4.

Upon vote, further consideration of Section 6, Article was postponed.

The sense but not the exact language of Section 7, Article VI., was adopted.

Section 8, Article VI., was adopted as read.

MR. DAVISON—I would move the adoption of Section 9, Article VI., after striking out the words *and of contracts and expenditures connected therewith*. These words conflict with Section 3 of Article VI. The Program Committee can make contracts but they must be approved by the Board.

It was voted that the sense of the Section be adopted.

Section 10, Article VI., was adopted as read.

Section 11, Article VI., was adopted as read.

It was voted that Section 1, Article VI., be adopted after striking out the sentence, "Thirty members shall constitute a quorum at this meeting."

On motion, the Committee of the Whole adjourned.

The Society was at once called to order by the President and on motion of Mr. Engstrom the report of the Committee of the Whole was ordered accepted and filed.

The meeting then adjourned.

REGINALD A. FESSENDEN,
Secretary.

MEETING OF THE CHEMICAL SECTION.

PITTSBURG, PA., April 21st, 1898.

The regular monthly meeting of the Chemical Section was held at 410 Penn Ave., April 21st., 1898.

In the absence of the chairman and vice chairman, W. E. Garrigues presided.

Dr. Phillips and Dr. Johnson read abstracts from recent chemical journals, which were briefly discussed by those present.

W. E. Garrigues read a paper on "The Determination of Lead in Alloys".

The meeting adjourned at 10.15 P.M.

A. G. McKenna,
Secretary C. S.

THE DETERMINATION OF LEAD IN ALLOYS.

BY W. E. GARRIGUES.

In the analysis of brass and bronze, the fact that we have only a single practicable method for separating lead is an unusual instance of poverty in the case of so common an element.

While the separation and determination as sulphate is admittedly excellent, there is always the more or less lengthy wait during evaporation of the filtrate from the metastannic acid, not to mention occasional losses of the assay at this stage through breakage. The latter is fortunately of rare occurrence and the former of little moment under ordinary circumstances, as no personal supervision is exacted during the operation, but it is not at all a rare occurrence that the foundryman wants his result at the earliest possible moment, and it is for such occasions that the following method is especially suited. Nevertheless, the determination is fully as accurate as that with sulphuric acid, and as it requires no more manipulation there is no reason why the method should not be employed at all times when the filtrate from the lead is not needed for other determinations.

The precipitation of lead as chromate, from neutral or acetic solutions, is an old and admirable process but it is inapplicable as a separation from copper—the latter being likewise thrown down. Copper chromate is known to be readily soluble in ammonia, but the writer has been unable to find any record of the behavior of ammonia toward lead chromate—the nearest approach being the statement that fixed caustic alkalis decompose it.

Experiment demonstrated that lead chromate is unaffected by ammonia and confirmed the ready solubility of copper chromate. Hence the perfect separation.

The analysis :

To the nitric acid solution of the lead and copper, is added an excess of potassium bichromate, followed by ammonia in decided excess. After heating until the supernatant liquid clears, the precipitate of lead chromate is filtered out on a Gooche crucible (the filtering medium being a single disk of filter paper), washed respectively with dilute ammonia, hot water, and alcohol and dried in the water oven ready for weighing. The results, in practice, have been found excellent.

In using the process, it must be remembered that the sulphate method is available where the chromate is not. The latter is essentially a separation from copper and zinc only. In the presence of antimony, for instance, it is entirely feasible to keep the small quantity—left in the filtrate from the tin—from coming down with lead sulphate, by the simple expedient of using a liberal amount of sulphuric acid, diluting sparingly, and filtering without undue delay. The same no doubt applies to bismuth. Both of these would obviously appear with the chromate of lead. Iron would likewise interfere in the latter case.

Having now described the chromate process as being more expeditious than the sulphate, there is the somewhat paradoxical position of having to explain how the reverse may be made the case—insomuch as the lead can be obtained directly, with-

out the necessity of first removing the tin. The process is rather delicate and its indiscriminate use may be objected to on this ground with some reason. It, nevertheless, seems possible to make the separation a clean and satisfactory one. At all events the observed facts are worthy of being recorded.

The description is perhaps best given in the form of an account of an experiment :

One half gramme of soft solder, containing: Lead 58.83 and 58.80 per cent. by the usual sulphate and chromate methods respectively, was oxidized with nitric acid, 20 cc. of strong sulphuric acid added, and the solution evaporated to the point of dense fuming. The metastannic acid was completely dissolved.

An addition of 80 cc. cold water was made, the solution stirred for a few minutes, and the lead sulphate filtered out on a Gooche crucible. The result for lead was 59.00 per cent.

The sulphuric acid filtrate was made alkaline with ammonia, again acid with sulphuric, but this time only until it turned methyl orange a decided red. The result was a voluminous white precipitate which was filtered out after boiling the liquid and which on ignition over the blast gave stannic oxide, equivalent to 41.1 per cent. tin. Total, 100.1.

If much more than 80 cc. was used for diluting the fuming acid, or if the diluted liquid was allowed to stand on the water bath for an hour or so, the tin began to precipitate slowly.

Antimony, when present in considerable quantity, sustains its reputation by coming down with both tin and lead and partly remaining in the last filtrate besides.

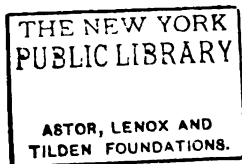
When it is desirable to remove lead and tin in one operation, as for instance in the determination of copper by the writer's thiocyanate method, it is essential to bear in mind the above described behavior of metastannic acid toward sulphuric acid and use the latter very sparingly. There is no difficulty in accomplishing the separation of both together in this man-

ner. One can even go a step farther—in the determination of zinc, as phosphate—by oxidizing with nitric acid, expelling the latter with as little sulphuric acid as possible, precipitating the copper as thiocyanate, and removing them all in one filtration. Three per cent. sulphuric acid washing, to prevent resolution of lead sulphate, has no effect on either the tin or copper precipitates.

Where small amounts of zinc alone are to be determined in bronze, this procedure is unequalled for accuracy, neatness, and dispatch.

The Duquesne Chemical Laboratory,
Pittsburg, Pa.





ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the society's house, 410 Penn avenue, Pittsburg, Pa., Tuesday evening, May 17th, 1898. The meeting was called to order at 8:40 P. M., by the President, Mr. George S. Davison, thirty-two members and visitors being present.

The minutes of the preceding meeting were read and approved.

For the Board of Directors, the following applicant was reported as passed and to be voted for at the next regular meeting: Mr. Danridge Cox, draughtsman with Riter-Connelly Co., Allegheny, Pa.

A consideration of the new constitution was voted postponed until after the reading of the paper of the evening, entitled "Gas and Gasoline Engines as Applied to Small Water Works Plants," which was then read by the author, Mr. Chas. O. Rogers.

GAS AND GASOLINE ENGINES AS APPLIED TO SMALL WATER WORKS PLANTS.

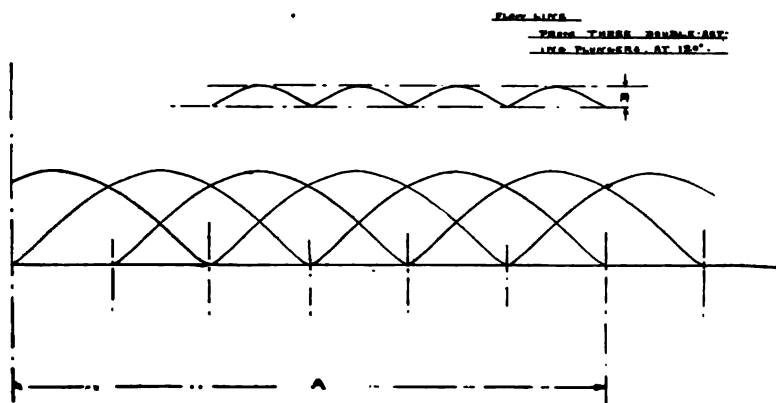
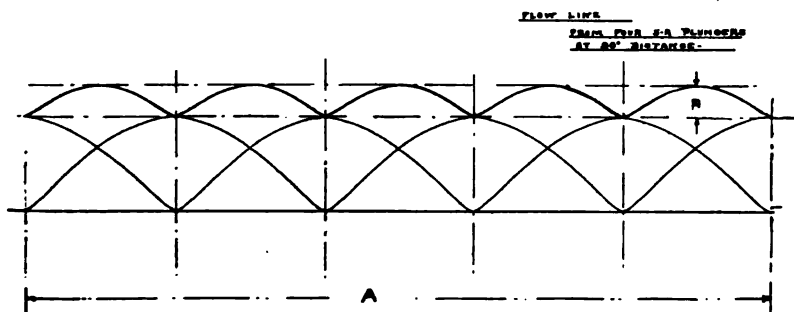
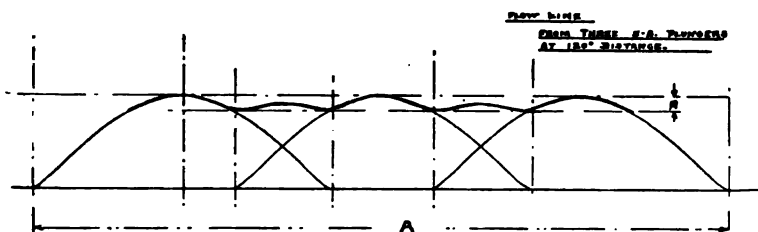
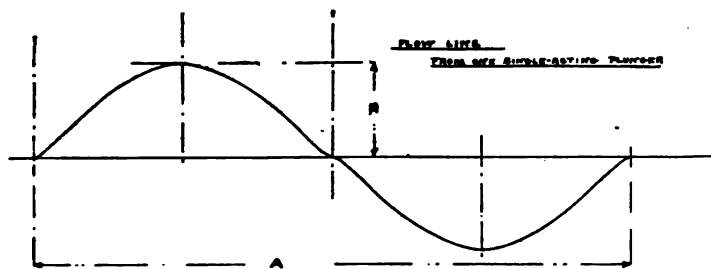
BY CHARLES O. ROGERS.

The number of small pumping plants for supplying water to towns and villages, to railroad supply tanks, and to like purposes is largely on the increase. This multiplication has forced upon the attention of engineers the available means for more economical operation. With coal at a nominal price

and a cast-off locomotive boiler as a starting point, the railroad engineer considered it sufficient to place a direct acting steam pump on tank service with a man in attendance, and the question was dismissed from his mind. But when the number of stations increases, the item of labor expense becomes one no longer negligible, and the fuel consumption is noticeable even on a railroad company's coal pile.

A duplex direct-acting steam pump of standard construction has the merit of being simple and self-contained, of always being ready to operate when supplied with steam direct from the boiler without the intervention of other motive power. It labors under the disadvantage of having to take a cylinder full of steam at each stroke and throw it away without using its expansive force. No fly-wheel, "tail-pincher" or other device for the storage of power in one part of stroke for delivery in another is considered to be desirable in pumps of less than about three million gallons per day capacity. With simple steam cylinders, it is fair to class these pumps as consuming about 120 lbs. water per horse-power hour, and upwards; compounded, at 60 lbs. to 75 lbs. water per horse-power hour. Expressed as pump duty, these are the equivalents, respectively, of say 20,000,000-ft. lbs. and 45,000,000-ft. lbs. per million heat units expended. High duty pumping engines, compound, condensing fly-wheel pump, attain a duty of 130,000,000 to 150,000,000.

To increase the efficiency of the small pumping unit, the power pump driven by a steam engine, either directly or through line shafting, is being adopted. The first style of power pump was like the steam pump with the driving gear substituted for the steam cylinder. Being horizontal, the weight of the moving parts working in more or less gritty water produces rapid wear. Floor space is usually an important item, also, and for many reasons a vertical style of power pump has been developed.





High Service Station at Pitcairn, Pa., East Pittsburgh Water Co.

Passing by the electrically-driven power pumping plant, the next chapter in its development brings in the gas engine. In the fall of 1896 the East Pittsburgh Water Company was obliged to install an auxiliary pumping station at Pitcairn, Pa. Its main lines supply the lower portions of the town and only a sparsely-settled district at the top of the hill remained to be looked after. For this high service duty, it was decided to use a gas engine and power pump, after Superintendent J. F. Miller and Engineers Wilkins & Davison had thoroughly canvassed the subject. The reasons which led to this decision were briefly these. The mains of the Philadelphia Gas Company afforded convenient and cheap fuel supply; the gas engine could always be ready for operation without the expense of banked fires; installation of boiler and stack, and carting of fuel supply were avoided. Moreover, the pipe line from which the suction of this pump must be taken is subject to heavy drafts for water at a point which took the supply from the pump. It must, therefore, be under automatic control, and not be liable to do itself or any other property an injury

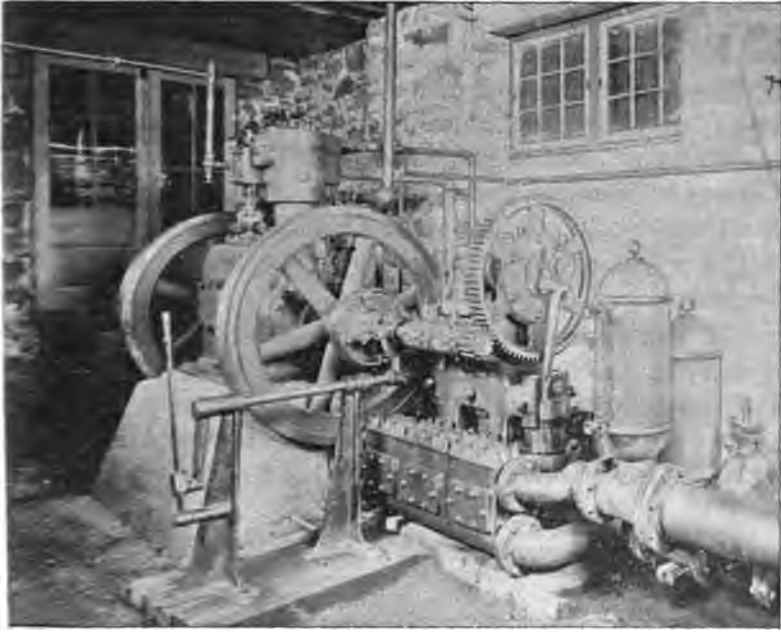
under these circumstances. The machines were finally installed as shown in the photograph. The engine was built by the Pierce-Crouch Engine Company, of New Brighton, Pa., and was guaranteed to furnish 25 horse-power at the brake on a gas consumption of 15 cubic feet per horse-power hour. The pump was an $8\frac{1}{2}$ "x8" single-acting triplex, built by the Deming Company, of Salem, and was guaranteed to deliver 225 gallons per minute of water against a head 325 ft. at the pump, with a power of 25 horse power.

The engine was belted to the pump with a 10 inch double belt, tight and loose pulleys on the pump. Discharge is through an 8 inch rising main to a steel tank of 190,000 gallons capacity 325 ft. above the pump.

The official trial of the plant took place in February, 1897, as follows :

Duration of tests.....	150 min.
Gas consumption by meter.....	608 cu. ft.
Total revolutions of pump.....	5,769
Average revolutions per minute.....	38.4
Revolutions lost by losing suction.....	525
Actual revolutions pumping water.....	5,234
Actual time pumping.....	136 min.
Average height of lift (discharge height less head on suction side).....	297 ft.
Weight water per stroke.....	49.26 lbs.
Average horse-power per hour when pumping.....	16.03
Horse-power to run pump and belt (established).....	3.42
Brake horse-power on engine.....	19.45
Gas consumed when not pumping (estimated).....	17 cu. ft.
Net gas consumed while pumping.....	591 cu. ft.
Average gas consumed per hour while pumping.....	261 cu. ft.
Gas consumption per brake horse-power.....	13.42 cu. ft.
Gas consumption per water-column horse-power.....	16.28 cu. ft.

Subsequently, similar plants were installed by the same company on essentially the same service at Wilmerding and East Pittsburg. The former is a 10"x12" Westinghouse gas engine, driving an $8\frac{1}{2}$ "x8" Deming pump against a head of 400 ft., capacity 275 gallons per minute, and on trial showed a fuel consumption of 14.26 feet gas per water-column horse-power.



High Service Station at East Pittsburg, Pa., East Pittsburg Water Co.

The latter plant is shown in cut and consists of an 8"x11" Westinghouse gas engine and the same size Deming pump speeded for a capacity of 275 gallons per minute at a head of about 240 ft. This plant showed a consumption of 18.82 cubic feet gas per water column horse-power. In both these latter cases, the belt was dispensed with, and pump was connected direct to engine by a friction cut-off coupling.

In the fall of 1897, the Freedom Water Company at Freedom, Pa., took up the matter of a waterworks pumping plant. The conditions were those commonly met with on the Ohio River bank. The pump station must be located on land which is subject to occasional overflows, and yet which is not within practicable suction reach of low water level. Mr. J. P. Leaf, of Rochester, was engineer in charge. As finally

decided upon, a 35 horse-power gas engine—Pierce-Crouch Company, of New Brighton, Pa.,—was erected on the floor of the engine room, raised on foundations out of high water reach. A masonry well was built to contain the pump, 25' deep from the engine room floor. The pump is a Deming triplex, $8\frac{1}{2}'' \times 8''$, of 325 gallons per minute capacity. An intake crib was sunk in the river bed and a 12" suction main laid direct to the bottom of the well. The discharge is to a reservoir on a hill somewhat over 3,000' distant, and 320' above the pump.

It was desired to fill the reservoir of 500,000 gallons capacity on the initial trial, necessitating a 24 hours' run. The pump revolutions were observed on a positively connected counter, and gauge readings checked up on duplicate gauges, tested and fairly accurate. The record of the test is as follows :

Duration of trial	24	hours
Average speed of pump.....	55	r. p. m.
Pressure on discharge, by gauge.....	138	lbs.
Equivalent head	318.6'	
Suction lift (by vac. gauge).....	7.	
<hr/>		
Total water lift.....	325.6	
Displacement per minute.....	324.5	gal.
Total water-column horse-power	26.68	
Gas by meter, total.....	11,300	cu. ft.
Gas per hour	470.83	cu. ft.
Gas per water column horse-power per hour.....	17.64	cu. ft.

As a comment on this test, it is fair to say that a leak has been since discovered in the gas pipe between the meter and the engine which may or may not have affected the results.

Records of actual tests made on similar water-works plants at Edgeworth, Pa., and New Castle, on railroad tank supply stations at Groveton, Sharon, and elsewhere, do not change the result above arrived at, even for a less capacity and lower head.

In the matter of gasoline as fuel, the records at present available are not quite as complete. At Dundee, Ill., a duplicate plant was installed in 1895, each unit consisting of a 35

horse-power Otto gasoline engine and a triplex pump—Deming Company—of 300 gallons per minute capacity. This plant has been in successful and economical operation, but the exact figures are not at hand.

At Hiram, Ohio, a water-works plant was completed and a partial test made on Oct. 25, 1897. A 10 horse-power gasoline engine made by the Advance Manufacturing Company, of Hamilton, O., is coupled to 5½"x8" Deming triplex pump. Water is pumped from a spring at the pump to a stand pipe against a head of about 215 ft. The gasoline is stored in a 50 gallon sheet iron tank beneath the ground outside the building, and supply is pumped to engine direct from this by a small pump on the engine for the purpose. For the purposes of the test, piping was disconnected and supply temporarily drawn from a vessel whose displacement was easily calculable.

Duration of test.....	20	min.
Pump speed.....	48	r. p. m.
Displacement per revolution.....	2.46	gal.
Displacement per minute.....	118.08	gal.
Pressure by gauge.....	98	lb.
Equivalent head	214.74	ft.
Gasoline consumption.....	.5266	gal.
Gasoline consumption per hour	1.58	gal.
Total water column horse-power	6.4	h. p.
Gasoline per horse-power hour .....	.247	gal.

In January last, the writer made a series of tests on a gasoline pumping plant of yet smaller capacity. At Midvale, N. J., the Erie R. R. has erected a water station, the pumping machinery consisting of a 5 horse-power Webster gasoline engine, and a 5½"x8" Deming triplex pump.

Duration of trial.....	7	hours.
Capacity (per minute).....	153	gal.
Total lift of water.....	65	ft.
Water column horse-power	2.51	
Total gasoline consumed ..	5.5	gal.
Gasoline per hour.....	.785	gal.
Gasoline per horse-power hour.....	.312	gal.

It is seen that even in exceedingly small plants the fuel cost is kept in some proportion to the duty as compared to

larger ones. The advantage to the Railroad Company above all saving in fuel expense is that of having a pump which does not require constant attention. One attendant can thus control several stations along the line, as on the P. & L. E. R. R., or an employé can handle the machinery with his other duties as at Midvale or Sharon. Expert attention is needed at intervals to insure proper conditions.

At Greensburg, Ind., there has recently been installed a tank supply outfit consisting of a 7"x8" Deming triplex pump driven by a 6 horse-power crude oil engine, made by the Indianapolis Engine Company, of Indianapolis, Ind. Its performance was as follows:

Duration of test.....	9	hours.
Discharge head (30-lb.).....	69.3	ft.
Suction lift.....	12	ft.
Total rise of water.....	81.3	ft.
Capacity of pump per revolution.....	4.0	gal.
Speed.....	46	r. p. m.
Displacement (per minute).....	184	gal.
Net water column horse-power.....	3.78	h. p.
Total fuel (Montpelier crude oil).....	16	gal.
Fuel per hour.....	1.778	gal.
Fuel per horse-power hour.....	.47	gal.
Cost of crude oil.....	2c	pr. gal.
Residue.....	9	gal.

In this engine the heat of exhaust gases passes through a reheater in which the crude oil is separated, the heavier parts going to the bottom and being drawn off, while the more volatile are consumed in the engine. The discussion of the interior features of the engine is left to gasoline engine experts; this is merely a report of the fact of the trial. The residue is used on the engine as lubricator, and is claimed to be the equal of an 8 or 10-cent lubricating oil. This allowed would make a balance in favor of running the engine nine hours of about \$40. In making duty comparisons of gas and gasoline pumping plants, the writer has found it difficult to obtain reliable and specific data regarding the calorific value of natural gas. As this value differs so widely in different pipes and even in the same pipes at different times, obviously

the only correct method is to make a gas analysis as an adjunct to each test. As cost renders this impracticable, we are left to estimate. The most reliable data are furnished by experiments of the National Transit Company and reported under date of Oct. 18, 1894, in proceedings of this Society. Accordingly we take 100 lbs. of coal, as equal in calorific value to 1,122.5 cubic feet gas, or 1 cubic foot natural gas=860 B. T. U. Also 1 lb. crude petroleum=21,000 B. T. U., and 1 gallon gasoline=125,000 B. T. U. In the table appended, natural gas is charged in at $22\frac{1}{2}c$ per 1,000 cubic feet and gasoline at 7c gallon.

6.6 lbs. per gallon crude oil.

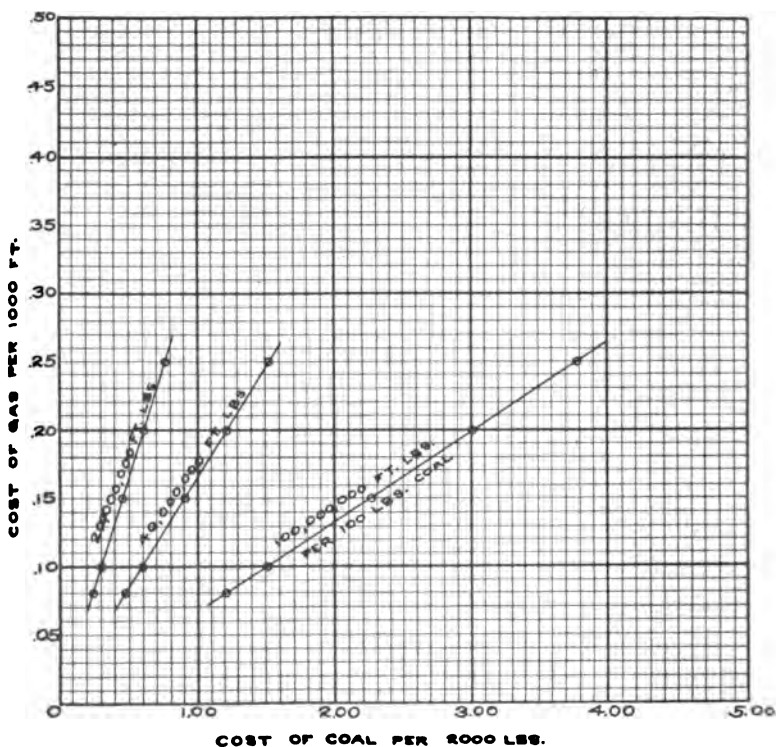
PLANT.	Duty per 100 lbs. coal.	Duty per 100,000,000	Cost net h. p. hour.
Akron.....	.....	.....	.....
Pitcairn, Pa.....	136,000,000	141,000,000	\$0.0037
Wilmerding.....	156,000,000	162,000,000	0.0032
East Pittsburg.....	118,000,000	122,000,000	0.0042
Freedom.....	126,000,000	130,680,000	0.0039
Hiram (gasoline).....	.....	64,000,000	0.0173
Midvale (gasoline).....	.....	50,700,000	0.0218
Greensburg (crude oil)....	.....	30,500,000	0.0094

These comparisons cover merely the net fuel cost, and make no account of other important considerations. Regarding durability and repairs, the gas engine in its present form is not yet sufficiently aged to speak from experience. With intelligent use, it promises to be as easy of maintenance in good repair as any steam plant. Strong points in its favor are that water can be forced into its mains in case of emergency at once, without waiting for banked fires to revive. Fuel consumption ceases at once when engine stops, and all fuel and waste are automatically taken care of by the machine itself.

In point of engineering, a gas engine plant is not as flexible as a steam plant. The economical speed of an engine is determined by its design and may only be varied within narrow limits. With the quality of gas known, its power can

be safely reckoned upon, and most economical service is usually obtained from an engine loaded to about 90% of its maximum capacity. Ease of operation and safety from accident and excessive wear dictate a somewhat lighter load, say about 80%.

The efficiency of the pump is variable between 60 and 90%. High pressures and large capacities give higher efficiency. Elimination of belting and close connections of engine and pump are economical both of floor space and power. The test at Akron, N. Y., already given is a fair sample of pump efficiency, though the belt absorbs an abnormal power by reason of an idler, which is usually unnecessary.



In conclusion is a diagram showing the price at which a ton of coal must be placed in the furnace of a steam pumping plant whose efficiency is known to equal the performance of gas at the stated price. This diagram is given in tabular form in a recent article by Mr. Geo. S. Davison on this subject, and it presents the comparative costs so clearly that it is reproduced with an apology to its author.

By this table it is seen that ten-cent gas equals dollar and a half coal in a compound condensing steam plant. These are fair working prices, but this efficiency is seldom obtained in a steam unit of less than 5,000,000 gallons per day.

DISCUSSION.

MR. GEO. S. DAVISON—One point that was not brought out by the author of the paper, and that is the remarkable evenness of the consumption of gas per brake horse-power in any given adjustment of the gas engine. In steam plants, while the engine is working on a constant load, there are so many conditions that may vary from the point of the feeding of the fuel to the boilers to the point of the engine doing work, that even a carefully conducted test lasting for from twelve to twenty-four hours, does not necessarily indicate upon what economy the plant may be operated as a whole. On the other hand, a short test of an hour or so can be taken as a sure indication of what a gas plant will do. I will illustrate this by a test which I made on one plant. I read the times in which the gas meter recorded a consumption of five cubic feet. I took ten of these readings. The first reading was 77 seconds; the second 79 seconds; the others were 78, 78, 77, 76, 80, 77, 77, 78. The average was 77.7 seconds, which average was maintained for two hours. In the ten readings above noted, the greatest variation from the average was only $2\frac{1}{2}$ per cent., and, of course, a portion of that difference was due to my inability to catch the reading of the meter and the watch on the instant.

PROF. FESSENDEN—In speaking of the evenness of the flow in duplex pumps, it has occurred to me that advantage has not been taken so far as I know of the fact that two plungers, one having its motion given by $\sin \theta$ and the other plunger having a motion $\cos \theta$, the sum of their velocities will always be constant. Consequently we could build a duplex pump the piston of which could be made to move in this way by a link motion which would give a perfectly uniform flow and all losses due to inertia and the eddy currents would be obviated, and furthermore, a much smaller fly wheel would be necessary.

I would like to ask Mr. Rogers if he knows of any reason why such a pump would not work well and be much more efficient.

MR. ROGERS—I think the losses in the present form would not be enough greater to warrant complication in driving gear.

MR. BOLE—What is the efficiency of the Wilmerding plant?

MR. ROGERS—It shows about one hundred and fifty-six million.

MR. BOLE—What is the best efficiency of any pumping plant yet tested?

MR. ROGERS—I believe about one hundred and fifty million.

MR. BOLE—I am greatly pleased and surprised that the gas engine does so well. I understand that the Allegheny City plant was guaranteed for one hundred million and the test gave one hundred and five to one hundred and six million. From what has been said this evening, it would seem that it does better than theirs.

What does the new Allegheny plant do?

MR. WILKINS—About one hundred and thirty million, I think.

MR. DAVISON—The results of the last tests have not been given out.

MR. BOLE—The statement is made that direct-acting steam pumps are generally used to do the work which is now being done by these triplex pumps driven by gas engines.

The direct-acting steam pump is a simple and hardy machine, capable of standing much neglect and abuse, but it also has the corresponding vice of being a most wasteful steam user, and when worn and in bad condition will often keep on pumping although at such extravagant cost of fuel that it would be economy for the owner if it would break down and refuse to run any longer. The amount of steam consumed per horse-power and per hour in such pumps, even when in fair condition, has been the subject of a good deal of investigation lately and a considerable number of cases have been measured.

In a recently published statement, one of the United States cruisers, I think the *Minneapolis*, had its machinery tested in detail for steam consumption, and some of the direct-acting steam pumps used over three hundred pounds of steam per horse-power hour. The main engine of such a vessel would probably use not over fifteen pounds steam per horse-power hour. Thus the accessory used twenty times as much steam to a given amount of work as the main engine. The gas engine will not stand as much indifference and inattention as such steam pumps but the tremendous fuel saving is worth taking a little pains to accomplish.

A lazy engineman may incline to prefer the steam pump, but his own labor would be greatly lessened by use of a gas-driver plant as there will be no coal shovel. Gas engines are particularly adapted for use as relay power.

At Niagara Falls at least one large concern has a gasoline engine (125 horse-power) for use in keeping certain of its processes continuous, in case the power from the Cataract Company should be interrupted. And it has been assured by the

user that the engine has paid for itself in only one or two stoppages which otherwise would have proven disastrous.

According to the figures of Mr. Rodgers, the efficiency of some of these gas driven pumping plants, although they are all very small, exceeds the efficiency of almost every steam pumping plant in the county, regardless of size or equipment.

Inasmuch as municipal pumping plants offer opportunity for the highest possible economy in steam consumption, and such plants far surpass any ordinary steam engine plant in efficiency, it will be apparent that this new comer, the gas engine, is bound to cut an important figure among the prime movers.

A MEMBER—What is the best efficiency of the gas engines?

MR. ROGERS—In the case of one of the plants mentioned in my paper, the total heat efficiency was about $17\frac{1}{2}$ per cent. from gas main to a water column, 88 to 85 from gas engine pulley to column, so that the efficiency of gas engine is 20 to 21 per cent.

What per cent. of the 80 per cent. was lost in the different ways; that is, how was it distributed from the engine?

MR. BOLE—The loss, like that of a steam engine, is mostly through the exhaust pipe and the jacket.

MR. DAVISON—I am somewhat familiar with the Wilmerding plant, as I made these tests together with Mr. Rogers. I would like to make a statement about the low gas consumption of another plant with which I have been connected. This was a Westinghouse gas engine of the same type as the Wilmerding engine, and was used for pumping a constant quantity of water under a known head. All the data for calculations were known except the efficiency of the pump, which was assumed as being 80 per cent.

The consumption of gas per horse-power hour of the work in the water column was 7.78 cubic feet. This was with a very rich gas, probably not less than 1,000 B. T. U.'s

per cubic foot, which, reduced by Jonle's equivalent, would be about 6,006,160 foot pounds. This yielding 1,980,000 foot pounds would indicate an efficiency of 33 per cent. from the fuel to the resultant work.

PROF. STEWART—It is claimed for the Diesel rational heat motor that a thermodynamic efficiency of 35 to 40 per cent. has been obtained, the compression of the charge being 710 pounds per square inch. So far as losses in the gas engine are concerned, they are due, as Mr. Bole has said, chiefly to the exhaust and the jacket water. So far as the cycle is concerned, the greatest efficiency is gotten by adding all the heat to the working fluid at the highest practicable temperature and rejecting what remains at the lowest practicable temperature. There is nothing phenomenal in the reported efficiency of the Diesel motor when we consider the very high initial pressure of about 700 pounds per square inch.

Prof. Stewart then drew on the board a diagram of the Diesel motor together with the indicator diagrams.

MR. BOLE—I would like to ask Mr. Rogers about the sizes of the gasoline engines.

MR. ROGERS—They run from one to ten horse-power and the test from .4 to .25 gal. per hour per horse-power fuel consumption.

MR. BOLE—The best result we have gotten is one-half gallon per horse-power hour in from ten to forty horse-power engines. Gasoline costs on an average, in tank cars, $4\frac{1}{2}$ cents per gallon.

MR. DAVISON—A 30 horse-power steam plant for pumping water should cost about \$100 per horse-power and a gas engine plant of the same size about \$90.

On motion, the meeting adjourned and the members partook of a lunch which had been prepared by the Reception Committee.

MEETING OF THE CHEMICAL SECTION.

PITTSBURG, May 19th, 1898.

The regular monthly meeting of the Chemical Section was held May 19th, 1898.

Chairman, J. O. Handy.

Attendance, 14.

The minutes of the last regular meeting were read and approved. Dr. Stahl mentioned that the *Chemiker Zeitung* and the *Berg u Huettenmaennische Zeitung* had apparently been discontinued. He requested an investigation and restoration.

Mr. Handy presented to the Section a bound copy of his index to the principal chemical and metallurgical works in the libraries of Pittsburg and Allegheny.

Dr. E. S. Johnson read the paper of the evening on Modern Dye Compounds.

A BRIEF REVIEW OF THE MORE IMPORTANT
SERIES OF ARTIFICIAL ORGANIC
DYE-STUFFS.

BY EDWARD S. JOHNSON.

II. COLORING MATTERS OF THE TRIPHENYLMETHANE,
ANTHRAQUINONE AND AZO-SERIES.

These selections from the list of artificial coloring matters have been made because of the scientific interest attaching to the substances comprehended, and of their superior technical importance.

The plan of their discussion has already been outlined. Remarks upon the *chemistry* of each series will be limited in the main to brief historical references and a review of important industrial formative reactions; attention will be called in

conclusion to certain relationships obtaining between chemical constitution and color. The treatment of the *manufacture* must be confined to short descriptions of the technology of the preparation of fuchsine or magenta, alizerine, and the azo-dyes in general. The coloring matters in their somewhat diversified *application* will have final consideration.

A. CHEMISTRY.

As the oldest and as having perhaps most generously contributed, through reseaches carried on among them, to the development of organic chemistry, the basis of the color-manufacture, it is fitting that first place be given the

TRIPHENYLMETHANES.

HISTORICAL SKETCH.¹

Through the action of ethylene chloride upon aniline at moderately high temperature, Natanson, in 1856, probably first obtained fuchsine, the pioneer of this series of colors. The reaction obtained by Natanson, however, gave the merest suggestion of what was to become an industrial product of wonderful success. The observation by Hofmann two years later, that carbon tetrachloride and aniline likewise yield a red substance of pronounced dye-stuff characteristics, became the principle of a process by which fuchsine was subsequently prepared on a manufacturing scale by Monnet & Dury of Lyons.

It was reserved for Verguin, professor at the Collége de Lyons, to discover the means for converting aniline into the red coloring matter in quantities which should first make it an object of commercial importance. Stannic chloride was the reagent. The process was placed for trial in the hands of Renard Frères, silk-dyers of Lyons. Fascinated with the

¹ Fuller details will be found in Schultz: *Chemie d. Steinkohlentheers*; Caro: *Ueber d. Entwicklung d. Theerfarben-Industrie*; Friedländer: *Fortschritte. Theerfarbenfabrikation*, I., II., III. Historical data regarding the remaining groups have been gathered from the same sources.

brilliant qualities of the dye, the firm immediately had the method of preparation protected by patents in both France and England in 1859.

The success of the color was fabulous, notwithstanding a cost-price of production even six years later of about four dollars per pound.¹ A monopoly for the manufacture was established, with a capital of nearly a million dollars, within a few years of its introduction.

The lucrative returns of the enterprise caused energetic effort on the part of inventor and capitalist to gain a footing in the industry. New methods of manufacture were therefore eagerly sought. Important for direct and indirect results should be mentioned the patents of Gerber-Keller, 1859, and Medlock, 1860, the former proposing mercuric nitrate and the latter *dry* arsenic acid for the oxidation of the aniline oil. The first named reagent was technically applied. Nicholson, of the firm of Simpson, Maule & Nicholson, manufacturing chemists, was destined, however, to become the most successful competitor through his *arsenic acid process*. It depended upon the action of arsenic acid in *concentrated solution* upon technical aniline; an English patent for the method was issued within a few days after that of Medlock had been granted.

Greatly improving the yield and producing a magenta still unequalled for handsome appearance, the new process held exclusive sway for a number of years. In evidence of its superior quality, the firm named displayed at the London Exposition of 1862 the famous "Magenta Crown," three feet in height, composed of magnificent crystals of rosaniline acetate. The solution in which the crown was formed had a value of forty thousand dollars.²

The poisonous character of the reagent employed in the preparation of fuchsine by Nicholson's method has always made a substitute desirable. Although still in use, it has largely

1 Caro: *Ueber d. Entw. d. Theerfarben-Industrie*. Ber. d. deutsch. chem. Ges. 25c, 1032.

2 Hofmann: *Chem. News* 6, 94; quoted by Caro: *Entw. d. Theerfarben-Ind.*

been superseded by the *nitrobenzene process* originating with Laurent and Castelhaz almost simultaneously with the arsenic process. Experiments of Coupier increased the efficiency of the method, and some years later it was developed to its present successful form through the efforts of the color-works of Meister, Lucius and Brünig of Höchst-am-Main.

In returning to consider other courses of development, the memorable researches of Hofmann among the aniline dye-stuffs should be especially emphasized. Their publication began in 1862. The first related to aniline red, fuchsine, and demonstrated that by whatever process produced the coloring matter is a salt of one and the same hydrous, colorless base to which the name rosaniline was given. The peculiar formation of neutral red, and acid yellow, salts, was commented upon, and the decolorizing action of reducing agents was shown to be due to the addition of two atoms of hydrogen. Diazo-compounds of both rosaniline and the reduced, anhydrous base, leucaniline, were described. In the following year it was ascertained that pure aniline in reaction with the various oxidants, tin chloride, mercury nitrate, arsenic acid, nitrobenzene, etc., applied with it for the production of fuchsine, does not yield the coloring matter; the toluidine present in the technical aniline was shown to be essential to its formation.

While the fuchsine manufacture had thus been progressing to its present industrial position and the knowledge of its chemistry developing, others of the triphenylmethane colors were being brought to notice and finding the popular fancy. Early in the history of the aniline colors, in 1860, Girard and de Laire had observed that fuchsine, upon being heated with aniline, underwent a very remarkable change in color from red through violet to deep blue. *Aniline blue*, by this method, still of importance among the dye-stuffs of the series, had been discovered. It at once became an industrial preparation, and soon attracted Hofmann's attention. His discovery that the new coloring matter is triphenylated rosaniline led to

the further introduction of the celebrated methyl- and ethyl-derivatives of the same base. *Hofmann's violet*, later *iodine-* and *methyl-green*, members of the group of alkylated rosanilines, are compounds which excited the wonder and admiration of the scientific and industrial chemical world of that day. Before advancing from the period in review, special mention should be made of *methyl violet*, a coloring matter discovered in 1861 by Lauth. It was not industrially produced, however, until 1867, when the numerous, at that time seemingly insurmountable, difficulties in the way of its preparation from dimethylaniline by oxidation, had been overcome by the discoverer together with Bardy. As simpler in its manufacture and less expensive than Hofmann's violet, it soon supplanted the latter in its position of great favor.

For a moment attention will be withdrawn from the *amidotriphenylmethanes* that the appearance of the important group of *phtaleines* may be duly noticed. The compound, *fluoresceine*, which should form the basis of a subsequent extensive manufacture, first became known through the researches of Baeyer in 1871. From it several years later, a list of colors unique in brilliancy was developed. The first representative appeared under the name of *eosine*, and was a discovery of Caro. The peculiar fiery beauty of the color won for it instant attention and unusual, lasting success. Its price,¹ at the time, of nearly one hundred dollars per pound was no hindrance.

The period in the history of the triphenylmethane coloring matters thus far hastily outlined has been characterized in its advance largely by empiricism. A new phase in development was soon to become apparent; it was the beginning of progress based upon a knowledge of the molecular structure, the constitution of these substances. Hitherto this had mainly consisted of surmises. In 1878, guided by earlier researches, contemporaneous, and their own, investigations,

¹ Caro: *Ueber d. Entw. d. Theerfarben-Industrie*, Ber d. deutsch. chem. Ges., 25c, 1049.

Caro and Gräbe proposed as the most probably correct constitutional formulas for rosaniline and rosolic acid, those now generally accepted. The same investigations had moreover shown the existence of the homologues, pararosaniline and pararosolic acid. The former were regarded respectively as simple modifications of triamido- and trioxydiphenyltolylmethane; the latter were held to be the corresponding derivatives of triphenylmethane. The same conclusion was reached simultaneously by Emil and Otto Fischer, who furnished decisive experimental evidence of the correctness of these views. A pure pararosaniline was prepared by them, and, by reduction, converted into paraleucaniline; this by diazotation and boiling with alcohol was deprived of its amido-groups. Thereby triphenylmethane was obtained. A regeneration of the coloring matter from the latter by nitration, reduction and oxidation completed the evidence of its relationship to the hydrocarbon, triphenylmethane. Already, in the new formulas, the three amido-groups had been represented as distributed one to each benzene-ring. Data had further been adduced, mainly by the experiments of Hofmann, Dale and Schorlemmer, and Caro and Gräbe, which indicated the presence of at least *two* of the amido-groups in paraposition to the methane carbon. Researches of E. and O. Fischer published in 1880 fully determined for all *three* this same relative position.

An immediate reflex upon the color-manufacture of the investigations unfolding the constitution of the rosaniline group was the opening of a period of rational synthesis. The greens of the series, the combinations by means of the hydrols, the phosgene colors, and the compounds developed from the condensation products of formaldehyde, are the cardinal achievements in the more recent history of the triphenylmethane coloring matters.

Leaving historical references, the effort will be to discuss in some detail the processes just suggested; they constitute in this series the principal

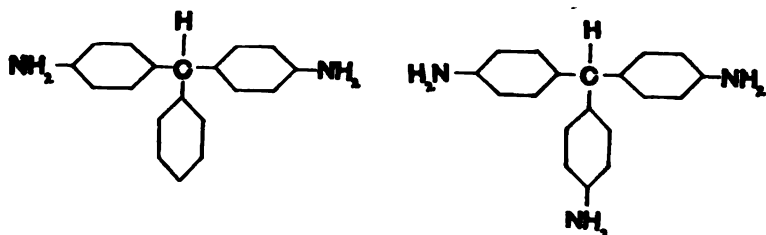
INDUSTRIAL FORMATIVE REACTIONS.

Those relating to the amido- and monocarboxylic compounds are first in interest as producing many colors of decided technical importance. The members of a third group, the trioxy-derivatives, are industrially of little worth; they are only sparingly used in the preparation of lakes and as indicators in the volumetric work of the analyst. In view of the large amount of more interesting material to be considered, they will be passed with this mention.

Comprising the oldest compounds and those most abundantly and variously applied, the amido-derivatives will appropriately engage first attention.

1. AMIDO-DERIVATIVES.

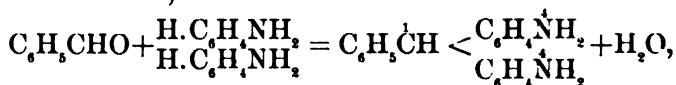
Of the known compounds of this character, only those have significance in the genesis of dye-stuffs, which contain two and three amido-groups in the para-position to the methane carbon atom, thus:



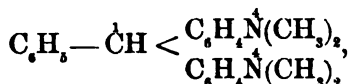
Diamido-

and Triamidotriphenylmethane.

These substances, and modifications in the form of simple derivatives, may be produced by the interesting *benzaldehyde condensations*. Benzaldehyde reacts with aniline, for instance, in the presence of zinc chloride or other absorbents for the water formed,



producing diamidotriphenylmethane. If instead of aniline dimethylaniline be used, the tetramethyl-derivative,



will plainly be produced. Substituting for benzaldehyde the the paranitro-compound, $\text{NO}_2-\text{C}_6\text{H}_4-\dot{\text{C}}\text{HO}$, in the latter process, and reducing, results in the formation of a triamidotriphenylmethane. The free amido-group may be alkylated or otherwise similarly substituted producing pentaalkyl-, hexaalkyl- or corresponding derivatives.¹ Using alkylated amidobenzaldehyde, such compounds have been directly obtained. While for di-amido-derivatives benzaldehyde condensations are the basis of technical productions, and have been almost since their introduction, they do not seem to have had important application until recently in the triamido-group².

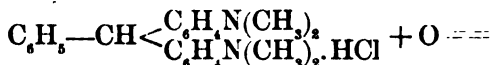
Before proceeding with the description of other synthetic reactions, certain general characteristics pertaining to the di- and triamido-derivatives under consideration should be referred to. The compounds whose formation is symbolized in the above equations are not coloring matters; they are even colorless substances. They possess strong basic qualities, imparted by their simple or substituted amido-groups, and form accordingly series of salts, corresponding in number with that of the amido-groups, which are likewise colorless. When subjected to mild oxidation in acid solution, (peroxide of lead, etc.) remarkable properties are developed: the colorless substance is suddenly transformed into one of great intensity of color, now, by this and other acquisitions, a dye-stuff. The latter, by reduction, is re-converted into the colorless body from which it was generated; this, as well known, is the *leuco-compound* of the coloring matter.

The cause of the striking change in properties ensuing in the oxidation of the leuco-base is not to be sought in the oxidation directly, nor in the formation of a salt. Oxidation

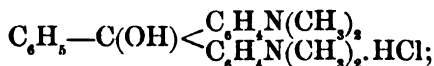
¹ Friedländer: I., 55; Germ. Pat., 16,707.

² Friedländer: III., 70; Germ. Pats., 70,905 and 72,032.

of itself simply introduces the hydroxyl-group in the place of the methane hydrogen producing a still colorless derivative, the *carbinol-base*. The salts of the base, however, are unstable and do not exist in most instances even in cold solution. A molecule of water is conceived to separate from the salt in the instant of its formation, and a partial redistribution of affinities within the molecule to take place. The resultant combination is the dye-stuff. To illustrate these transformations, the conversion of the condensation-product of benzaldehyde and dimethylaniline into a coloring matter may be followed in the equations:

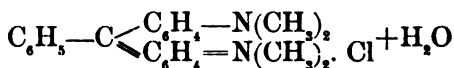


Leuco-base chloride.



Carbinol-base chloride.

the latter after the separation of water becomes:



Carbidride¹ chloride (coloring matter).

The formation of the colorless salt of the carbinol-base may be observed in certain cases. In the cold the base dissolves in acid, and gradually on standing, but rapidly when its solution is heated, the anhydrization occurs with the phenomenon to which attention has already been called.

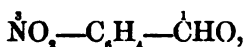
The *rearrangement of affinities* accompanying the reaction should be especially noted as that which wholly or in part gives specific character to each triphenylmethane dye-stuff; its existence (among the phtaleines, together with a configuration resembling the xanthonering) is regarded in other words,

¹ "Carbidride" is a contraction for "carbinol anhydride;" Schultz u. Julius: *Tabellar. Uebersicht d. Künstl. organ. Farbstoffe*, 3te Aufl., p. 96.

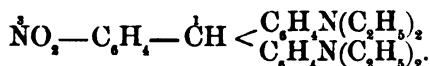
as the cause to which its striking behavior toward light, and in general as a coloring matter may be referred.

In the form of oxalate, sulphate, chloride (zinc double salt), etc., tetraalkylated diamidotriphenylcarbide under various names, such as *malachite green*, *benzaldehyde green*, *brilliant green*, with others of similar principle of nomenclature, appears upon the market. The composition of the chloride is shown by the last of the above formulas.

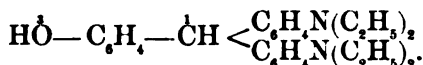
By the same general method, applying instead of benzaldehyde its metanitro-derivatative and transformations of the leuco-base to be noted, a green blue coloring matter of importance has been produced. Metanitrobenzaldehyde,



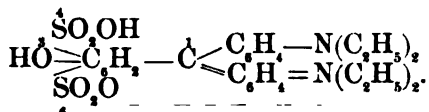
combined with diethylaniline yields



Reducing, diazotizing and boiling with water give the meta-oxyleuco-base,



By sulphonation two sulphonic groups are introduced in the positions 4, 6, in the benzene-ring containing the hydroxyl-group. Oxidation develops the carbide or dye-stuff,

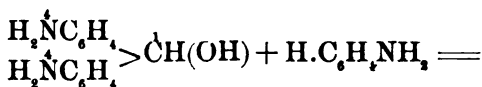


The calcium or sodium salt is the well-known *patent blue*.

The use of the benzaldehyde condensation in the preparation of colors of the triamido-group, in particular *parafuchsine* and its homologues, will be considered in a later connec-

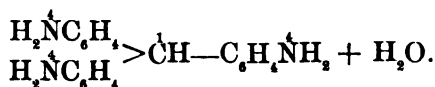
tion, with the fuchsine manufacture. The formation of the leuco-bases has already been typically presented.

The *benzhydrol condensations* are valuable reactions for the preparation of these compounds in a multiplicity of modifications. The hydroxyl of the hydrol is highly reactive and unites readily with the para-hydrogen of primary, secondary and tertiary aromatic monamines, separates as water, and is substituted by the amine-rest; the combinations resulting, as implied, are triamidated triphenylmethanes. The equation will serve to illustrate the reaction:



Diamidobenzhydrol.

Aniline.

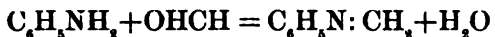


Triamidotriphenylmethane.

Employing the alkylated, phenylated, benzylated, naphthylated monamines, others containing mixtures of the radicals indicated, and sulphonated amines of the same description, and combining with variously and similarly substituted hydrols, leuco-bases in great variety and large number will be formed. Oxidation as before finishes the process. The benzhydrols for the earlier¹ condensations were derived by the reduction of diamidobenzophenone and its substitution products. Latterly² they have also been prepared by the oxidation of corresponding diamidodiphenylmethane derivatives. These are now obtained by the most important and productive of recent synthetic methods, the *formaldehyde condensations* with aromatic amines. The reaction between aniline and formaldehyde represents the process in its simplest form:

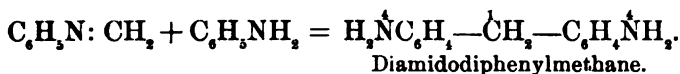
1. Friedländer: *Fortschritte d. Theerfarbenfabrikation* I, 75; Germ. Pat. 27032.

2 For instance, see Friedländer: *Fortschritte d. Theerfarbenfabrikation*, III., 116; Germ. Pat., 63017.



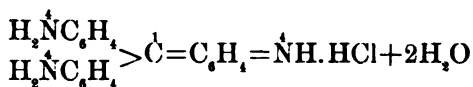
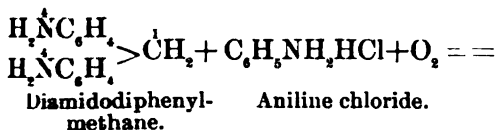
Aniline. Formaldehyde. Anhydroformaldehydeaniline.

The anhydro-compound when heated with aniline chloride in the presence of a large excess of aniline combines with the latter to diamidodiphenylmethane:¹



Secondary and tertiary amines react without the intermediate formation of the anhydro-compound after the manner of combinations with benzaldehyde. Diamidodiphenylmethanes by oxidation are converted into diamidobenzhydrols, which are combined and transformed into coloring matters as just described. Following the suggestions then made, in the preparation of diphenylmethanes, it is obvious that the reaction is one of great possibilities.

The oxidation of diamidodiphenylmethane with aniline and of diamidodiorthotolylmethane with orthotoluidine affords a method of producing *parafuchsine*, and its homologue, *neufuchsine*, so advantageously as to offer noteworthy competition with the preparation from the nitrobenzene process, a mixture of pararosaniline and rosaniline salts.² The reaction for parafuchsine comprehending the oxidation of diphenylmethane to diamidobenzhydrol, the condensation to the leucobase, the conversion into the coloring matter, is expressed in contracted form in the equation :

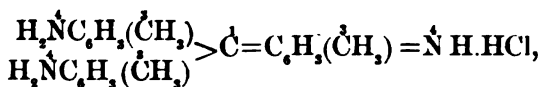


Parafuchsine (pararosaniline chloride; tri-p-amidotriphenylcarbidride chloride).

¹ Germ. Pat., 53937: Friedländer, II., 53.

² Friedländer: III. 112, 113: Germ. Pats. 61,146 and 59,775.

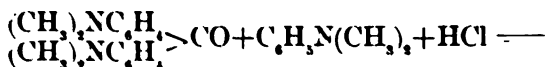
In like manner new fuchsine, tri-p-amidotri-m-tolylcarbide chloride,



is obtained. Diamidodiorthotolylmethane being formed by heating diamidodiphenylmethane with orthotoluidine chloride, it may be replaced in the process by this mixture.

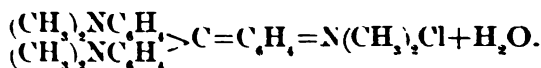
The formative reactions as yet outlined have two phases, the formation of the leuco-compound and its oxidation to the coloring matter. The operations for realizing the processes may be separate, requiring the isolation of the former before oxidation, as in the benzaldehyde condensations; in the case of certain of the hydrols, the phases are affected without isolation. The preparation is a continuous operation.

The process for the so-called *phosgene colors* also involves a single operation and has but one phase. It depends upon the combination of diamidobenzophenone and aromatic amines, and derivatives of both of a nature similar to those repeatedly mentioned or identical with them. The presence of an energetic condensing agent such as zinc chloride, aluminum chloride, phosphorus trichloride, and others of like effect is required. An example of the condensation will be found in the equation :



Tetramethyldiamido-
benzophenone.

Dimethylaniline.

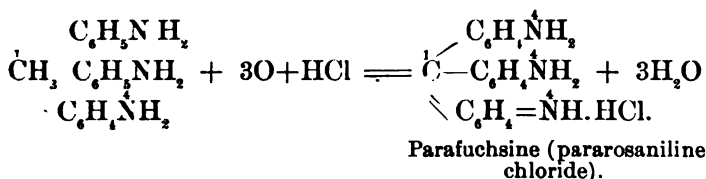


Crystal violet (hexamethylparosaniline
chloride).

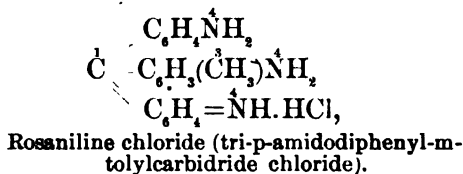
The alkylated benzophenone, which is formed by the action of alkylated amines upon carbon oxychloride, is not necessarily used as such, but may be replaced by the calculated molecular

mixture of the compounds from which it is produced.¹ Where the amines employed are heterogeneous, the ketone-molecule usually becomes an initial ingredient of the condensation.

The old empirical method upon which the fuchsine manufacture was founded and according to which it still operates, should have attention in conclusion. It consists in the *oxidation of "red oil"* mentioned in references to the preparation of intermediate products. This, a mixture of aniline and toluidine (ortho- and para-), is oxidized with arsenic acid, or nitrobenzene in the presence of an oxygen transmitter. Most simply expressed the reaction is a union of two molecules of aniline with one of paratoluidine. A salt, arsenic or hydrochloric acid being present, of pararosaniline results:



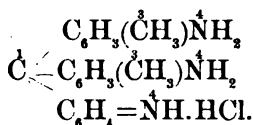
In the equation it is indicated that the methane carbon has been supplied by the methyl-group of the *paratoluidine*. This is a constitutional essential to the reaction, as was demonstrated by the researches of Hofmann. If orthotoluidine be present, as is always the case in the technical process, the homologue, rosaniline,



is likewise formed. Similarly two molecules of orthotoluidine with one of its para-isomer give rise to a tri-p-amidophenyldi-m-tolylcarbide chloride:

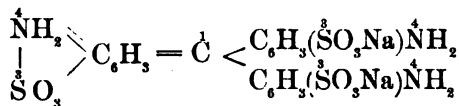
¹ Friedländer: I., 78; Germ. Pat., 26,016 and 29,943.

² Id.: I., 80; Germ. Pat., 27,789.



The result of oxidizing the toluidines or aniline alone is negative as regards the formation of triphenylmethanes. In the case of paratoluidine, the para-position is taken; aniline and the remaining toluidines do not possess the necessary methyl-group, the former not at all, the latter not in the required (para-) position. The methyl-group, in the process, is supposed to become active in combination by first being oxidized to the aldehyde-group,—CHO, when the familiar condensation occurs.

The sulphonation of fuchsine produces an extensively employed preparation, a mixture of the trisulphonic acids of pararosaniline and rosaniline, *acid fuchsine*:



Sodium salt of pararosanilinetrisulphonic acid.

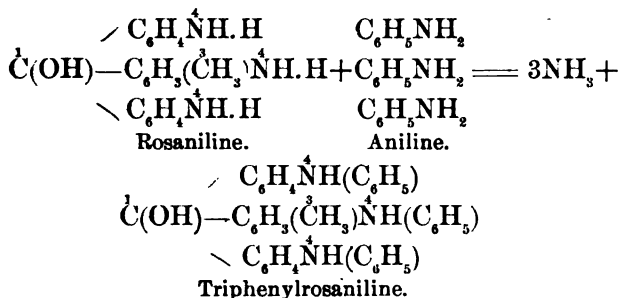
The modified compound is available as a dye-stuff for mixture with the acid colors applied in the dyeing of silk and wool *in acid bath*, a desirable but impossible practice with fuchsine before this invention of the use of sulphonation.¹ The appearance of acid fuchsine initiated an important technical development, vastly expanding the usefulness of the basic triphenyl-methane colors.

Sulphonation with the object of simply *increasing the solubility* of a coloring matter had been utilized long before² its application to fuchsine for the purpose explained, besides in connection with indigo, with the mixture of triphenylpararosaniline and -rosaniline obtained by the action of aniline in the presence of benzoic acid (in general, a monobasic organic acid) at about 180°C upon the bases of fuchsine.

¹ H. Caro in 1877; Bad. Anl. u. Sodaf., Germ. Pat. 2,096.

² Nicholson in 1862.

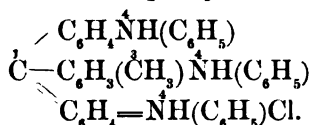
The phenylation proceeds with the escape of three molecules of ammonia :



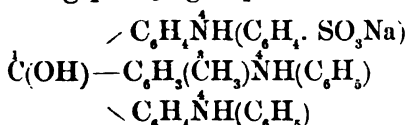
After separation as chlorides the triphenyl derivatives obtained undergo sulphonation.

The preparations of the combined processes are the several varieties of empirical aniline blue. The chloride of the unsulphonated compound is *sprit blue*, *Gentian blue*, etc.

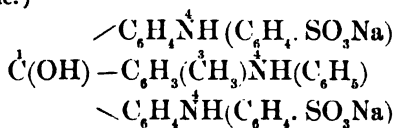
Its main constituent is triphenylrosaniline chloride :



The sodium salts of the mono-, di-, and trisulphonic acids are current under, among others, the names *alkali blue* or *Nicholson's blue*, *marine blue*, and *cotton* or *soluble blue*. As seen in the formulas, which represent the characterizing compounds of the colors, the sulpho-groups have entered the substituting phenyl-groups :

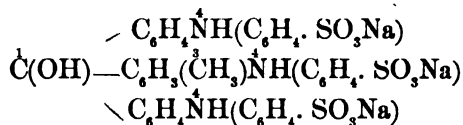


Sodium salt of triphenylrosanilinemonosulphonic acid (Nicholson's blue.)



Sodium salt of triphenylrosanilinedisulphonic acid (marine blue.)

and

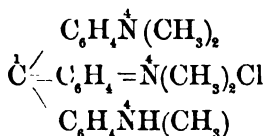


Sodium salt of triphenylrosanilinetrisulphonic acid (cotton blue.)

Whether or not the distribution of the sulpho-groups in the mono- and di-derivatives is as shown, with respect to the diphenylamine-rests or the phenyltolylamine-rest, is as yet a matter of mere conjecture. It is not improbable that both preparations are mixtures of the isomeric compounds possible in each case.

The hydroxyl of the formulas is a peculiar feature and an expression of the fact that the *salts* of the sulphonic acids are colorless and constituted like the bases of the group. The *free acids* have the color of the salts of triphenylrosaniline, and in all probability are of analogous constitution.¹

The gentle *oxidation of dimethylated* (-ethylated, etc.,) *aniline* produces in partial analogy with what has been said upon the fuchsine reaction, the corresponding derivatives of triamidotriphenylmethane. The methane carbon, however, is supplied by a methyl-group combined, not with carbon, but with nitrogen. A pentamethylated product is therefore largely obtained instead of a pure hexamethyl-compound, as yielded by formative reactions already discussed:



Pentamethylpararosaniline chloride (a main constituent of methyl violet).

The process is the basis of the important *methyl violet* manufacture.

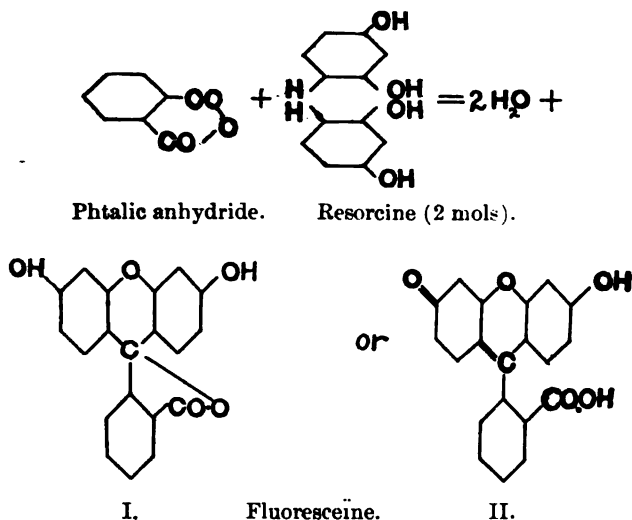
¹ Compare formulas of rosaniline and its triphenyl-derivative, and of pararosaniline-trisulphonic acid.

The reactions thus hastily considered must suffice to indicate the manner of preparation and the chemical relations of the amidotriphenylmethane colors.

2. PHTALEINES.

The phtaleines are products of the action of phtalic anhydride upon certain phenols. Principal among these is resorcline, metadioxybenzene, after which the compounds of the group are frequently designated "resorcline" dyes.

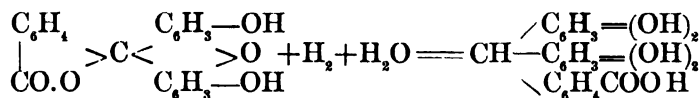
The type of these bodies is fluoresceïne; its formation, in fusion at a temperature of about 200°C., and constitution are represented by the following formulas:



An oxygen atom from a carbonyl-group (CO=) in the anhydride has united with an atom of hydrogen from each resorcline molecule in ortho-position to one of the two hydroxyls, separating as water. Anhydridization of the hydroxyls also occurs. In the formulas representing fluoresceïne, a triphenylmethane-derivative will be at once recognized. Differences in the main features of the constitution are also prominent. One of these

is the configuration formed by two carbon atoms from each resorcine-rest, an oxygen atom from either, and the carbon atom of the anhydride to which the resorcine-rests are bound ; it is regarded as the constitutional cause of the remarkable colorific properties of fluoresceïne as displayed in the splendid fluorescence of its salt solutions. Formula I represents the constitution of such derivatives ; the properties of others, for instance the halogen substitution products, have induced, as more competent to their explanation, the assumption of the tautomeric formula II.

Analogous to its amido-relatives the phtaleïnes are converted by reduction into phtalines, colorless bodies, the leuco-compounds of the group. Upon oxidation they revert to the original phtaleïne, the coloring matter :



Fluoresceïne (phtaleïne.)

Fluoresceine (phtaline.)

The simplest derivative of fluoresceïne, possessing the properties of a dye-stuff is its sodium salt, *uranine*, a yellow dye of but limited application.

When two and four halogen atoms are substituted for hydrogen red coloring matters of peculiar beauty and brilliance of shade are derived. Tetrabromfluoresceïne in the form of sodium and potassium salts is the celebrated *eosine*. The corresponding iodine compound is otherwise known as *erythrosine*. In shade it contains a suggestion of blue. The halogen substitution takes place in the resorcine-rests.

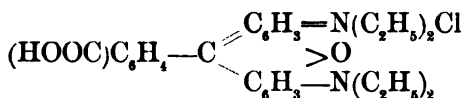
If instead of phtalic anhydride the dichlor-derivative be used in the fluoresceïne fusion, dichlorfluoresceïne results. This subjected to treatment with bromine and iodine gives rise to further red compounds varying in shade and other qualities which make them valued preparations. The salts of the tetrabrom-product are technically known as *phloxines* ; those

derived similarly with iodine from di- and tetrachlorfluoresceïne are varieties of the beautiful *rose de bengale*.

By the nitration of dibromfluoresceïne a fine combination passing under various names, *eosine scarlet*, *imperial red*, etc., is obtained.

In this round of substitution nearly every hydrogen atom of the three benzene-rings has been replaced, in part together, in part successively. The carboxyl hydrogen has also been made an object of substitution with the formation of methyl- and ethylesters. In the case of tetrabromfluoresceïne they are the *sprit eosines*, being used in alcoholic solution.

The climax, in point of beauty and largely in technical value, among the phtaleïnes is reached in the magnificent *rhodamines*, the salts of tetraalkyldiamidofluoresceïne :



in which, it will be observed, the hydroxyl-groups of fluoresceïne have been replaced by substituted amido-groups.

One of the methods of preparation is similar to that for the phtaleïnes in general, alkylated metaamidophenol being fused with phtalic anhydride.

Vicinal trioxybenzene also reacts, as do the phenols already mentioned, with the anhydride with the formation of a phtaleïne. During the fusion oxidation occurs, thereby producing the dye-stuff, *galleïne*. Heated with sulphuric acid the condensation is continued, a further molecule of water being separated. *Ceruleïne*, the product of the reaction and an important color in calico-printing, is, as well as a phtaleïne, also an anthraquinone.

Relative to the properties of the triphenylmethane dye-stuffs as such, it may be said that they display a great variety of brilliant colors of extraordinary intensity. They are in a greater and less degree sensitive to light, and are by no means

as permanent under other influences, such as washing, as is desirable for many purposes. Nevertheless, they are widely applied where such defects are more tolerable.

ANTHRAQUINONES.

HISTORICAL SKETCH.

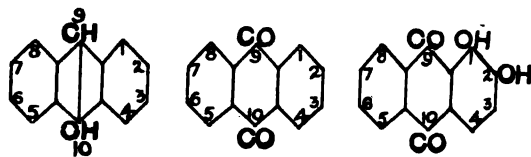
The anthraquinone dyes are by far the most important of the artificial coloring matters. The principal of these, alizerine, is a constituent of the root of the madder plant. Its valuable qualities have caused the cultivation of the plant for centuries, first in the countries of the Orient on a small scale, and much later, in the sixteenth century, more extensively in Europe, particularly in France, Germany and Holland.² In 1789 the production had reached, for that time, such vast proportions that exportations of the dye-stuff from France (the single province of Provence) to England represented a value of \$750,000; from Alsace alone in the year following, 5,000,000 lbs. of madder were exported. It is further estimated that the total yearly production of the world in the years immediately preceding 1868 aggregated 70,000 tons. In that year it was observed by Gräbe and Liebermann that alizerine by reduction is converted into anthracene. The probability of the artificial production of the coloring matter from this source stimulated to strenuous efforts for its realization. In the following year Gräbe and Liebermann were able to announce a solution of the problem. Their process, however, proved too expensive for successful competition with nature, based as it was upon dibromanthraquinone. It was nevertheless patented in England and became the property of the Badische Anilin u. Soda-Fabrik, with which the patentees had united interests in the development of their discovery. In this establishment, together with Heinrich Caro, and almost simultaneously in England by Perkin, the method which should become a technical success was invented in the same year, 1869. With modifica-

2 Schultze: *Die Chemie d. Steinkohlentheers*, 2te. Aufl., II., 584.

tions increasing the yield, it is essentially the present, prevailing process, and consists in the fusion of anthraquinone sulphonic acid with caustic alkali. The German investigators presented the invention to the English patent-office, and the day following the almost identical process was entered by Perkin. This coincidence resulted in a fusion of interests and the foundation of the existing extensive manufacture.

INDUSTRIAL FORMATIVE REACTIONS.

The researches which have just been mentioned and others conducted in the same period established in the main the constitution of the colors of the alizerine series, showing them to be directly related to anthraquinone. As this substance is formed by oxidation from anthracene, they are also to be regarded, in a broader sense, as derived from that hydrocarbon. In the formulas these relationships are plainly exhibited :



Anthracene.

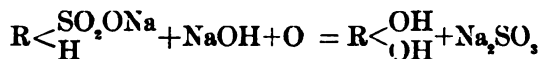
Anthraquinone.

Alizerine.

Anthraquinone itself is totally devoid of the essential properties of a coloring matter, but possesses, nevertheless, great capacity for the development of compounds which display such qualities in a remarkable degree. Its colorific energy is rendered active by the introduction of at least two hydroxyls, one of which, if an efficient dye-stuff be formed, must be to the other and to a ketone oxygen in ortho-position. The compound answering to this requirement, dioxyanthraquinone 1.2., and its derivatives comprise the substances from which a fine array of coloring matters have been generated.

As phenols the general method of preparation for dioxo- and trioxyanthraquinones is through the medium of the sul-

phonic acids in fusion with caustic alkali. Unlike phenols of simpler constitution, the *mono*-sulphonic acid produces a *di*oxyanthraquinone, and a *di*-sulphonic acid a *trioxy*anthraquinone, oxygen for the additional hydroxyl being absorbed from whatever available source it presents itself during fusion after the normal formation of respectively a mono- and a di-oxy-derivative. In the first technical fusions it was supplied mainly from the atmosphere; at present it is added in the form of potassium chlorate. The simple reaction will be plain from the equation, R being the anthraquinone-rest :



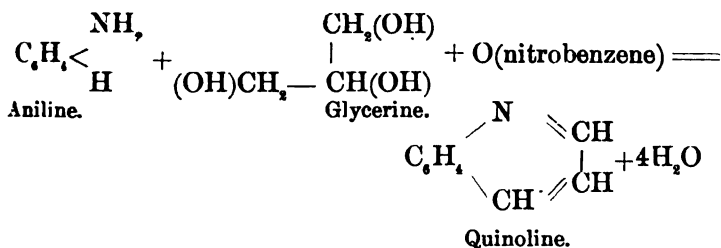
In this manner dioxyanthraquinone 1.2, *alizerine*, and trioxyanthraquinones 1.2.7. and 1.2.6., *isopurpurine* and *flavopurpurine*, are obtained, the first from the betamono-sulphonic acid, the remaining respectively from beta- and alpha-disulphonic acid. By other methods which the limited space prevents discussing, hydroxyls to the number of six have been substituted. A tetraoxyanthraquinone 1.2.5.8, *alizerine bordeaux*, a penta-oxy-derivative, 1.2.4.5.8, *alizerine cyanine*, and two hexaoxy-compounds, *rufgallol* and *anthracene blue*, are applied as coloring matters.

Several of the oxyanthraquinones have been found to develop useful characteristics in a number of more or less simple derivatives. Mononitroalizerine and -purpurine, for instance, are familiar substances in the practice of the dyer and are known as varieties of *alizerine orange*.

The monosulphonic acid 1.2.4. is the largest source of *alizerine carmine*.

The reduction of the alphanitro-compound results in *amidoalizerine* or *alizerine garnet*; its relative, *amido-purpurine*, is the *alizerine maroon* of the trade.

When aniline and glycerine are heated with nitrobenzene and concentrated sulphuric acid, as discovered by Skraup, quinoline is formed in the manner indicated in the equation :

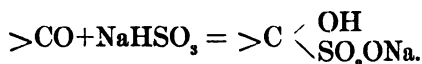


The reaction takes an entirely similar course with amidoanthraquinones. From alpha- and beta-amidoalizarine, and from amido-3-flavopurpurine compounds of this nature have been obtained. They are respectively an *alizerine green*, *blue* and *black* of the series.

As oxy-derivatives the anthraquinone dyes form salts. In general these are intensely colored and exist in a profusion of shades. The color of the salt or *lake*, as the compound is designated, varies with the same anthraquinone through a wide range, according to the metal participating in the salt formation. Aluminium with alizerine, for example, produces a scarlet lake; that with iron is violet, and with chromium violet brown in color. The salts of the alkali metals are soluble in water; those of the metals of other groups are distinguished for great insolubility.

These compounds cannot be applied directly, as in the case of the salts of the basic triphenylmethane colors, or the resorcine dyes; they are developed upon the materials to be dyed by first impregnating or "mordanting" them with the salts of the required metals, and then bringing the materials thus prepared in contact with the anthraquinone compound. This of itself, although it exhibits affinity for certain of the textile fibres, is worthless as a coloring matter; the metallic compounds, therefore, are the actual dye-stuffs.

The sparing solubility of the alizerine colors, in some instances, is an obstacle in the way of their application. This has been removed by conversion into a bisulphite compound which possesses the desired quality. Being ketones, the anthraquinone derivatives form additive compounds with alkali bisulphites, after the manner of their simpler analogons. Using a single ketone, the reaction is :



Anthraquinones as double ketones combine with two molecules of bisulphite. Alizerine quinolines are prepared in this form for example.

Producing handsome and varied colorations unexcelled but rarely equalled in every variety of fastness, the alizerine dyes are prime favorites, and in general stand in highest estimation among the artificial colors.

AZO-COLORS.

HISTORICAL SKETCH.

The technical history of the azo-coloring matters began with the introduction of chrysoïdine in 1876. The scientific foundation of the industry then initiated was established by preceding researches of J. P. Griess on the diazo-compounds of the aromatic series. His method for the preparation of amido-compounds of azo-benzene by the action of aromatic amines upon diazo-benzene is the prototype of the present technical process for the manufacture, not only of amido-dyes, but for every species of azo-dye-stuff.

The first of these bodies was discovered by Griess, afterwards jointly studied by him and Martius. The first showed it to be amidoazobenzene. As *aniline yellow* it became an object of manufacture in 1863 by the English firm of Messrs. Maule & Nicholson. Martius' *Bismarck brown* was the first color of the series. From the time of its appearance

until the discovery of chrysoidine, first by Caro and very shortly afterwards by Witt, a period of inactivity prevailed. With the bringing out of chrysoidine by Witt, the possibilities of the azo-colors foretold by Griess began to be realized, and a rapid course of development ensued.

Chrysoidine was followed by the *orange coloring matters* prepared by Roussin in the color-works of Poirrier, and discovered independently at the same time by Witt and in part (dimethylorange) by Griess. These substances were made by combination of sulphanilic acid (diazotized) with dimethylaniline, diphenylamine and the naptols. The use of sulphanilic acid suggested further experiment with the analogous acid of the naphthalene series, Pira's naphthionic acid. Caro, by this means, prepared the first red azo-dye-stuff, *fast red*. The discovery proved of radical importance to the industry in leading to the synthesis of some of its most valuable products.

Baum's investigation of the sulphonation of the naptols, more especially betanaphtol, marked the beginning of further advance. In the course of it two of the most important disulphonic acids of betanaphtol, familiarly known to the manufacturer as "R" and "G" acids, were discovered; their application caused the production of a number of scarlet colors of fine quality, and far-reaching improvement in the principles of the manufacture.

In 1877 Caro and Schraube observed that the amidoazobenzenes could be further diazotized and thus used as simple amines for combination according to the method of Greiss; the compounds obtained contain the azo-group, $-N=N-$, twice. The first color of this character was Nietzki's *Biebrich scarlet*.

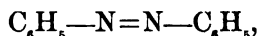
A recent is also one of the most significant periods in the history of the azo-coloring matters. Böttiger in 1883 discovered the peculiar property of the colors obtained by the action of the naphthylamine sulphonic acids upon diazotized

benzidine of directly fix themselves upon cotton fibre without the use of mordants. A new and extensive field was thereby opened to the application of the azo-dyes with a corresponding expansion of the manufacture.

Perhaps the most important of recent progress may be said to center in the compounds produced with the dioxy-naphtalenes (and other oxy-components), mordant dyes, of which various lakes are generated upon the fibre after the parent dioxy-color has been fixed upon it.

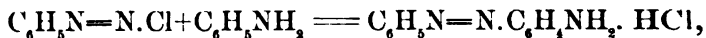
THE SYNTHESIS OF THE AZO- COLORING MATTERS.

That which chemically characterizes the compounds of the azo-series of dye-stuffs is the presence of the complex, $-N=N-$, two nitrogen atoms united by double bonds, and each in addition with the phenyl-group, similar aromatic radicals, or their derivatives. The simplest compound of this constitution would therefore be



azobenzene. A whole host of substances has been prepared which may be referred to it as generatrix; of these a large portion comprises the coloring matters under consideration. The principles of their preparation and their further nature and relationships will be briefly discussed.

Although highly colored, azobenzene is lacking in an essential characteristic of a dye-stuff, an affinity for the textile fibres at least in part. This, however, is developed by the substitution of hydroxyl- or amido-groups. Technically such derivatives are not prepared directly, but as before intimated, by means of diazo-compounds together with amines and phenols. Thus diazobenzene chloride and aniline yield amidoazobenzene:

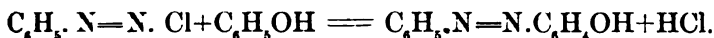


Diazobenzene chloride. Aniline. Amidoazobenzene chloride.

disregarding the intermediate formation of diazoamidobenzene



Similarly oxyazobenzene is formed where phenol and diazobenzene are combined :



Diazobenzene chloride. Phenol.

Oxyazobenzene.

From more or less complex derivatives of both members of each equation an exceedingly large number of compounds with one azo-group becomes possible. They are the *monoazo-dyes*. An almost equally large number with two, three and four azo-groups, the *disazo-colors*, has been synthesized.

For the first group the bases principally used, in diazotized form, and represented in the typical equations by aniline, are, besides this amine, toluidine, xyloidine, anisidine, cumidine, the naphthylamines, and a number of simpler derivatives, such as meta- and paranitraniline, sulphanilic and metanilic acids, and the sulphonic acids of the naphthylamines.

For combination or "coupling" with these, numerous amines and phenols are available. They include among them, apart from some of the compounds just mentioned, dimethylaniline, diphenylamine, metaphenylenediamine, salicylic acid, the naphthols, their mono-, isomeric di- and trisulphonic acids, amidoxy- and dioxynaphthalenemono- and -disulphonic acids, and resorcline.

Using in the main diazo-compounds of amidoazobenzene, -naphthalene, the paradiamines, such as benzidine, toluidine, amidocarbazol and amidostilbene, and combining similarly, disazo-colors in great variety have been produced.

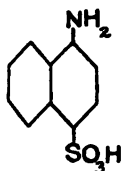
Among the cited intermediate products of the manufacture, the sulphonic acids of the naphthols, naphthylamines, and several amidoxy- and dioxynaphthalenes are of extraordinary importance. Baum's discovery and introduction of the isomeric R and G disulphonic acids, and the success achieved by them have been mentioned. In their application it first became clearly apparent that both the *number* and *position* of the sulphonic groups must also be taken into account in the develop-

ment of characteristic dye-stuff qualities ; a plain corollary of the proposition is the necessity of applying these isomeric sulphonic acids, and also other components, in a state of purity as far as their congeners are concerned.

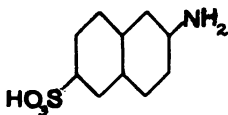
Remarkable differences in the shades of the colorations produced by the dye-stuffs formed from the same diazo-compound were observed by Baum according as the R- or G- acid became the second component. The preparations with R-acid range in color from reddish orange to blue red ; the isomer gave to the colors derived from it in comparison a yellowish tone. Increased intensity, clearness and general beauty of effect in the colorings denoted material advance over the results hitherto obtained with the mixtures of isomeric disulphonic acids then customarily in use. Incited by the notable success of these first of the betanaph-toldisulphonic acids, an energetic and general study of the sulphonation of naphthalene derivatives was inaugurated with the object, if possible, of discovering others of the hundreds of theoretically possible naphthalene sulphonic acids, and observing the influence of the new bodies as components of azo-colors. When it is stated that dioxynaphthalenemonosulphonic acids alone exist theoretically to the number of forty-two, it will be seen that an extensive field for investigation is open to cultivation. Not all of the acids discovered by studies already instituted, nor even a large portion of them, may be said to have technical value. Twenty odd are recorded as objects of manufacture, not preparations of the scientific laboratory alone whence they emanated, and as components of the azo-dyes of the present. By way of illustrating the preceding statements, and also as facilitating an understanding of the constitution of the colors of which they are constituent parts, the structural formulas of several of the more extensively used oxy- and amidonaphthalenesulphonic acids are appended¹ :

¹ Schultz u. Julius: *Tabellar Uebersicht d. Künstl. org. Farbstoffe*. 3 te Aufl.; Friedländer: I, 347, 402; II, 230; III, 404.

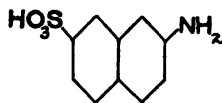
See also Nietzki: *Chemie d. organ. Farbstoffe*, 2 te Aufl., pp. 49-51.



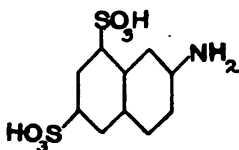
Alphanaphthylamine-
monosulphonic acid 1.
4. (naphthionic acid).



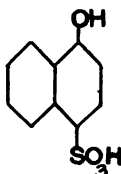
Betanaphthylamine-
monosulphonic acid 2.
6. (Brönner's acid).



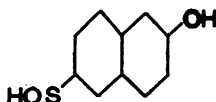
Betanaphthylamine-
monosulphonic acid 2.
7. (F-acid).



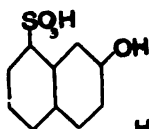
Betanaphthylamine-
disulphonic acid 2. 6. 8.
(for naphthol black).



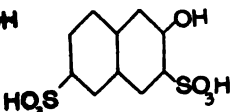
Alphanaphtholmono-
sulphonic acid 1. 4.
(Neville-Winter's acid)



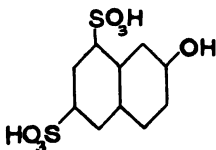
Betanaphtholmonosul-
phonic acid 2. 6. (Schäf-
fer's acid).



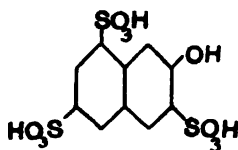
Betanaphtholmonosul-
phonic acid 2. 8 (croce-
ine acid).



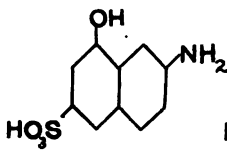
Betanaphtholdisul-
phonic acid 2. 3. 6.
(Baum's R-acid).



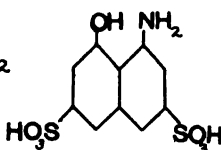
Betanaphtholdisul-
phonic acid 2. 6. 8.
(Baum's G-acid).



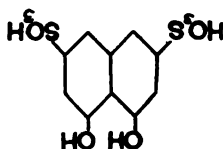
Betanaphtholtrisul-
phonic acid 2. 3. 6. 8.



Amidooxynaphtha-
lenemonosulphonic
acid 2. 8. 6. (Y-acid).



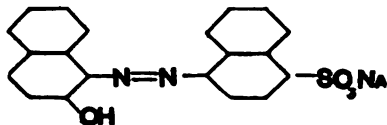
Amidooxynaphtha-
lenedisulphonic acid 1.
8. 3. 6. (H-acid).



Dioxynaphthalenedi-
sulphonic acid 1. 8. 3. 6.
(chromotrope acid).

To name and formulate even a few of the nearly three hundred dye-stuffs of the azo- series at present manufactured would be to no purpose. The technical names are derived from a marked characteristic, a component of the coloring matter, in a few instances from that of the discoverer or inventor, or are based upon some local allusion; altogether, it would be an unprofitable proceeding. Attention is requested to the individual color by means of the collection exhibited.

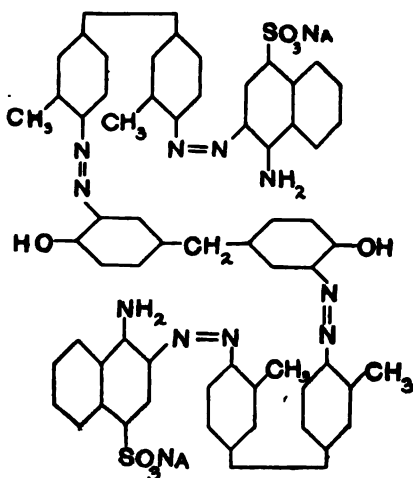
The formulas of a simpler and more complex azo-compound will be sufficiently illustrative in this respect, and will serve the further purpose of aiding in a brief consideration of interesting generalizations regarding the union of diazo-compounds with the oxy- and amido-derivatives of benzene and naphthalene. I have selected *fast red* for its historical and present industrial importance, and *azo-orange*,¹ a recent, somewhat complicated tetrazo-color formed by the combination of two molecules of diazoorthotolidine with two of naphthionic acid and one molecule of paradioxydiphenylmethane:



I.

Fast Red.

¹ Schultz u. Julius: *Tabellar. Uebersicht*, p. 96.



II.

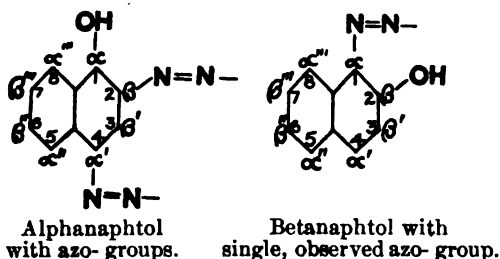
Azo-Orange.

The azo-group of the diazo-compound attaches itself with preference, when combining with a substituted benzene or naphthalene, in para-position to the hydroxyl- or amido-group present. When a free para-position does not exist in the nucleus, the ortho-position is assumed, and, in the naphthalene series, in particular the *alpha*-ortho-position. Thus in formula I attachment has taken place in the nucleus of the betanaphtol in this position to the hydroxyl. A case of *beta*-ortho-union is shown in formula II, where a diazo-group of diazotolidine and the naphthionic acid molecule are represented in this relation. The other of the tolidine diazo-groups has taken the ortho-position to the hydroxyl of the diphenylmethane molecule. When the *alpha*-ortho-position is also filled, combination can not be effected as exemplified by alphanaphtol derivatives in which the positions 2 and 4 are occupied.

The observation that betanaphtol can bind one azo-group only while two may be united to the isomeric compound is but another illustration of these peculiar predispositions in substitution. An inspection of the formulas will make plain the

manner of the attachment. In the alpha-compound it is in the positions 2 and 4. It has been found that no combination occurs in the case of betanaphtol if already substituted in the alpha-ortho-position; a para-position in the compound is not available.

A dependence of the properties of the coloring matter produced upon the place of substitution becomes apparent in a marked degree in colors derived from the naphthols. Ortho-substitution yields much more serviceable dyes than those formed by a para-substitution of the azo-group. It is for this reason that betanaphtol coloring matters excel in the requisite qualities those from alphanaphtol. By the use of the latter with substituted para-position, the quality of the colors obtained is much improved; beta-ortho-entrance of the azo-group then takes place with the production of fast and useful dye-stuffs.¹

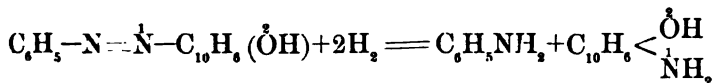


The dioxybenzenes, resorcine, hydroquinone and pyrochatechin, also exhibit preferential peculiarities in uniting with the azo-group. Resorcine has long been applied in the preparation of azo-colors, but it is only comparatively recently that a combination with pyrochatechin and hydroquinone has been effected.² The combinations, however, are purely of scientific interest, having as dye-stuffs no significance. The original compounds prepared with hydroquinone accompany the collection.

¹ Nietzki: *Chemie d. organ. Farbstoffe*, 2 te Aufl., pp. 46-49.

² Otto N. Witt u. Friedrich Mayer: *Ber. d. deutsch. chem. Ges.* 24, 1072; Otto N. Witt u. Ed. S. Johnson: *Ber. d. deutsch. chem. Ges.* 25, 1908.

Like all dye-stuffs, those of the azo-series are converted by addition of hydrogen into colorless compounds. By the gentle reduction of certain azo-compounds, the azo group is transformed into the colorless hydrazo-group, $-\text{NH}-\text{NH}-$. A more energetic action of reducing agents splits up the molecule of the compound into two molecules, the original amido-compound from which the diazo-body was prepared for combination and an amido-derivative of the second component. For instance, anilineazobetanaphtol, when reduced with stannous chloride, adds hydrogen and separates into aniline and amido-oxy-naphtalene 1. 2.:



The reaction in general has been found of great value in studying the constitution of the azo-compounds and as a means of their identification.

When it is possible to effect a partial reduction, to the hydrazo-compound only, the azo-compound may be regenerated by oxidation. The former is therefore to be regarded as the leuco-body in the azo-series.

The azo- coloring matters exhibit a great diversity of properties. The scale of color represented comprehends shades of yellow, orange, red, scarlet, blue, blue black, jet and the recently added greens. Among them are basic, acid (phenolic and sulphonic derivatives), and mordant colors. They display all degrees of permanence under the circumstances of their application and service, comprising some extremely fugitive, a large number of satisfactorily, and some (mordant) unusually, fast dye-stuffs. In all branches of tincorial work they are extensively consumed.

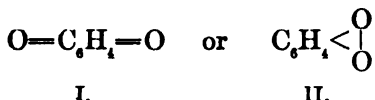
CHEMICAL CONSTITUTION AND COLOR.

As to the atomic cause of color, the manner in which the atoms of certain molecules of a substance which is described

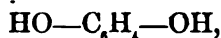
as colored retain a portion of the rays of light falling upon them and diffuse a remnant which is called color, it must be said that absolutely nothing is known. Unmistakable relations between the phenomenon of color and molecular structure have, however, been established by the investigations through which the constitution, especially of the artificial, organic dye-stuffs, became revealed.

The first generalization upon the subject was that announced in 1867 by Gräbe and Liebermann. By them attention was called to the fact that each colored organic compound is to be conceived as derived by oxidation from a colorless substance; the former, it was pointed out, may be caused by reduction to reproduce the original compound. In many cases the reduction consists in the simple addition of hydrogen; in others, of a more severe attack upon the molecule, and involves a substitution of hydrogen for oxygen. Instances of transformations from colorless to colored will be recalled in the oxidation of paraleucaniline to parafuchsine, and in related compounds; fluoresceine of familiar tinctorial properties is the oxidation product of colorless tetraoxytriphenylmethanemono-orthocarboxylic acid; colorless hydrazobenzene becomes under a similar agency red azobenzene; the slightly colored anthraquinone is formed from anthracene, etc. Further illustration of the general principle is found in the class of nitro-bodies. Most of them are in a greater or less degree colored; the products formed by the action of nascent hydrogen upon them, the corresponding amido-derivatives, are devoid of color. The reaction in these instances is not reversible. The nitro-compounds may nevertheless be looked upon as being indirectly oxidation products of the amido-derivatives formed from them by reduction.

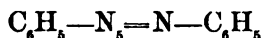
The quinones, in particular the simplest, benzoquinone, served Gräbe and Liebermann in the original communication as a pointed example. It is familiar that benzoquinone,



by reduction loses its yellow color and becomes hydroquinone,



again a colorless body; in its reversion by oxidation to quinone, the oxygen atoms become doubly bound to carbon, or, according to an older view of the constitution of quinone, as represented in formula II, are united to each other and each to a carbon atom; in hydroquinone they were attached by single bonds. The formation of azobenzene,



from hydrazobenzene is attended by a double binding of nitrogen atoms which before were joined by a single bond. These and other reactions of similar character led to the advancement of the theory that in this *more intimate* or *intense union* of the atoms of the molecule is to be sought an explanation of the colorific properties of the oxidation product. Nitrogen and oxygen were named by the originators of the theory as frequently participating in such concentration of energy in organic compounds, and, therefore, especially prolific in the formation of colored substances.

These first interpretations of the relationship of constitution and color formed the nucleus which has since developed into the present extended conception. According to this a specific phase of the molecular structure, a particular complex of atoms, is recognized in each colored compound of known constitution as the cause of its selective absorption of light; such atomic complexes have been designated *chromophores* by Witt.

Given a compound already possessed of color, and containing, therefore, a chromophoric group, the color of the substance is modified in quality in progression toward blue from yellow through red by the massing of atoms into one

great molecule by substitution directly or indirectly in the simpler molecule, a fact to which attention was first directed by Nietzki. The familiar and well-adapted instance to be taken from the first group of compounds considered, the triamidotriphenylmethanes, may be cited in illustration. The substitution of hydrogen in the amido-groups by *methyl* changes fuchsine red to violet, most pronounced when all the hydrogen atoms have been replaced, as in the hexamethyl-compound, the beautiful crystal violet. The hexa*ethyl* derivative is still deeper in tone, and the introduction of three *phenyl*-groups produces a blue of purest quality.

The same general relationship is to be observed among the azo-dyes. Its clearness is, however, often somewhat blurred by the complications introduced by the nature, number and position of the numerous radicals occurring in the components with the attendant influence upon the shade. The following azo-compounds¹ with gradually increasing number of methyl-groups, as in the case of methylated fuchsine, clearly display a progression of color, in this case, from orange toward blue :

DYE-STUFF.	COLOR.
$\text{C}_6\text{H}_5-\text{N}=\text{N}-\text{C}_{10}\text{H}_5(\overset{1}{\text{OH}})(\text{SO}_2\text{OH})_2$	Orange.
$(\overset{1}{\text{CH}_3})\text{C}_6\text{H}_4-\overset{4}{\text{N}}=\text{N}-\text{C}_{10}\text{H}_5(\overset{2}{\text{OH}})(\text{SO}_2\text{OH})_2$	Reddish orange.
$(\text{CH}_3)_2\text{C}_6\text{H}_3-\text{N}=\text{N}-\text{C}_{10}\text{H}_5(\overset{2}{\text{OH}})(\text{SO}_2\text{OH})_2$	Scarlet.
$(\text{CH}_3)_3\text{C}_6\text{H}_2-\text{N}=\text{N}-\text{C}_{10}\text{H}_5(\overset{2}{\text{OH}})(\text{SO}_2\text{OH})_2$	Bluish scarlet.

In general it may be said, the influences mentioned being born in mind, that coloring matters with an aniline-rest for each component are yellow in color. If a naphthalene-rest be present with aniline, shades of orange and red prevail. Two naphthalene-rests give rise to orange in its deeper shades, but in the main to reds, scarlets, and, in a few instances, bluish reds. The blues, blue blacks, and blacks of the series are to be

¹ Meldola: *Azo-Colors* in Thorpe's Dict. of Applied Chem.

found among the complicated disazo-compounds, although orange, red and brown in various shades have numerous representatives.

Enthusiastically reviewing the achievements of the period concerning the synthesis of coloring matters, Hofmann¹ once put the question: "Will not chemistry finally teach us to systematically build up dye-stuff molecules whose particular shade of color may be predicted with the same certainty with which we at present determine in advance the boiling-point and other physical properties of the creations of our theoretical conceptions?"

Although this advanced state of development is still to be attained, confidence in the eventual fulfillment of Hofmann's prophetic query may be hopefully entertained; notable progress has already been made toward its realization.

On motion of Dr. Phillips a vote of thanks was extended to the author of the paper.

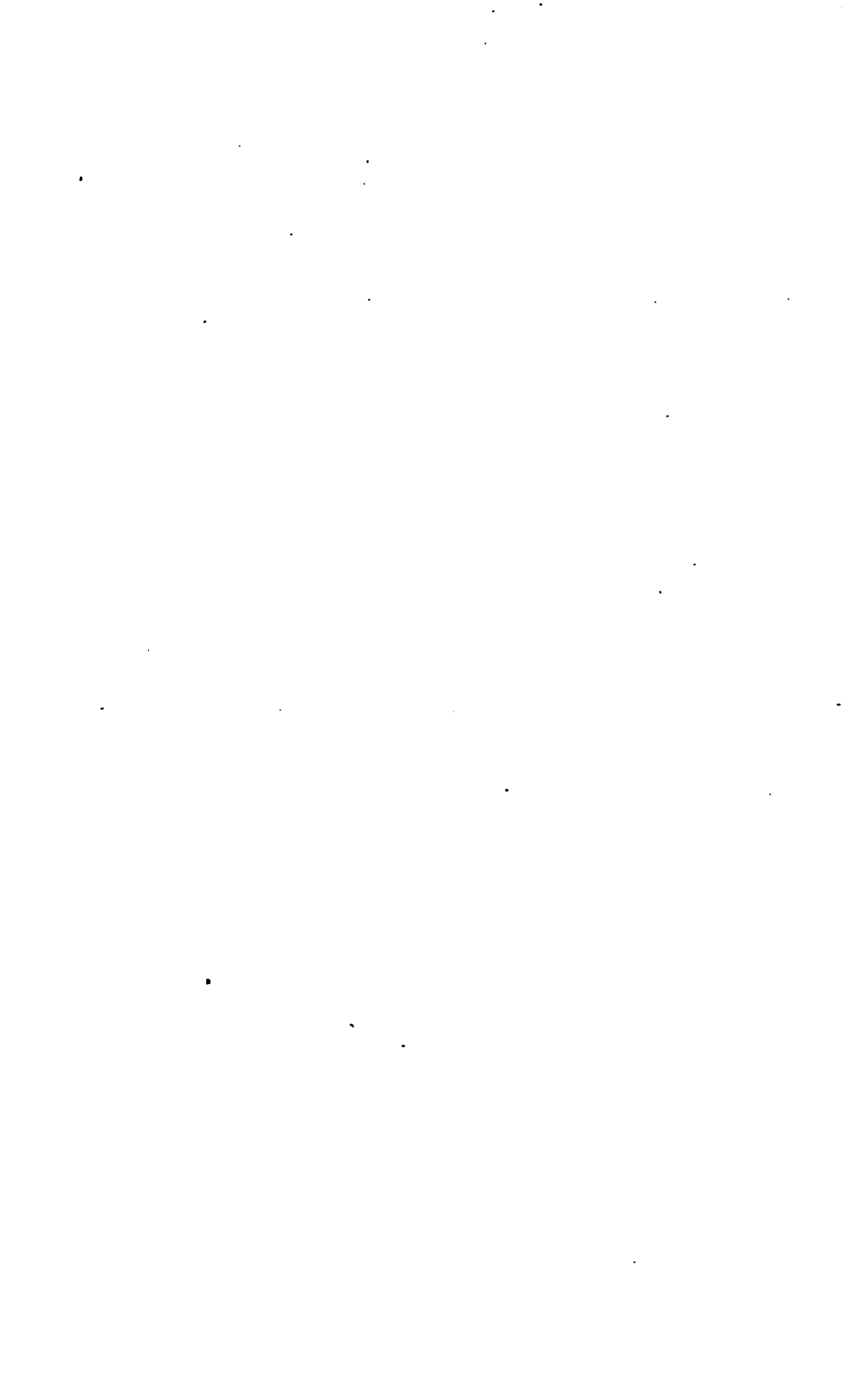
Mr. Garrigues spoke of a recent experience in the determination of chromium in ore by fusion with sodium peroxide. He found no difficulty in securing complete decomposition of the ore, but found some chromium remained insoluble in the alkaline solution of the fusion. On the addition of sulphuric acid to the unfiltered solution it does not become clear until the ferrous sulphate is added in the titration and the results are very much too high. By heating the solution after the addition of the acid a clear solution is obtained and results are concordant and correct.

It was suggested that the insoluble matter might contain ferrate salts, which are only decomposed slowly by cold sulphuric acid and by action on the ferrous sulphate would give high results.

Section adjourned at 10.20 P. M.

A. G. McKenna, *Secretary S. C.*

¹ Caro: *Entw. d. Theerfarben-Industrie*, Ber. d. deutsch. chem. Ges. 25C, 1002.



ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the Society's house, 410 Penn avenue, Pittsburg, Pa., Tuesday evening, June 21, 1898. The meeting was called to order at 8:15 P. M., by the President, Mr. George S. Davison, forty-two members and visitors being present.

The minutes of the preceding meeting were read and approved.

Mr. Danridge Cox, draughtsman with Riter-Connelly Co., Allegheny, Pa., was balloted for and elected to membership.

It was voted to postpone discussion on the new constitution until after the reading and discussion of the paper of the evening.

For the House Committee Mr. Lyons reported that the order for book-cases had been awarded to the Iron City Hard Wood Finishing Company for \$59, and that the cases would be placed in the Lecture Room within a week.

The President notified the House Committee to have the house cleaned and also the carpets during the summer months.

Mr. Kaufman, for the Program Committee, said that he knew that it was the intention of the committee to have a series of papers on the manufacture of iron and steel and to solicit authors for the papers.

PRESIDENT—The subjects for the papers are as follows :

- | | |
|-----------------------------------|------------------------------|
| 1—Mining of Iron Ores. | 7—Bessemer Steel, (a) Acid, |
| 2—Transportation of Iron Ores. | (b) Basic. |
| 3—Manufacture of Pig Iron. | 8—Manufacture of Open-hearth |
| 4—Foundry Practice. | Steel (Acid). |
| 5—Malleable Castings. | 9—Manufacture of Open-hearth |
| 6—Wrought Iron Making. | Steel (Basic.) |
| 10—Manufacture of Crucible Steel. | |

We would like to have suggestions so that we can get the committee after authors.

Mr. Hohl, for the Library Committee, reported that the scheme for arranging and cataloguing the books had been practically completed and that as soon as the cases were in place the committee would finish the work.

The President, in behalf of the Reception Committee, stated that Mr. Beutner had arranged an excursion for the Society to the new town of Vandergrift, which could still be carried out if the Society felt inclined to do so and would instruct the Reception Committee to complete the necessary arrangements. After some discussion it was voted that the Reception Committee be instructed to arrange for the excursion.

Professor Phillips presented a book to the Society entitled "Methods for the Analysis of Ores, Pig Iron and Steel; in Use at the Laboratories of the Iron and Steel Works about Pittsburg." The contents of the book consisted of a series of papers which had been read before this Society in 1896, and had been arranged and published in book form by the Mechanical Publishing Company, of Easton, Pa.

Mr. E. Floyd Preston then read a paper on "The Smoke Nuisance, and Its Possible Abatement by a Process of Distillation," after which Mr. Robert L. Walker read a paper on "The Economical Combustion of Fuel and The Prevention of Smoke."

THE SMOKE NUISANCE.

ITS POSSIBLE ABATEMENT BY A PROCESS OF DISTILLATION.

BY E. FLOYD PRESTON.

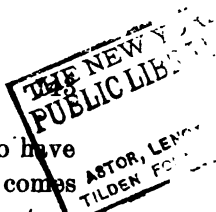
In a treatment of this subject it seems necessary to determine just what it is that constitutes the real nuisance of smoke. A lady writer in one of our dailies some month since, gave her opinion of what constitutes the nuisance of smoke, as follows:

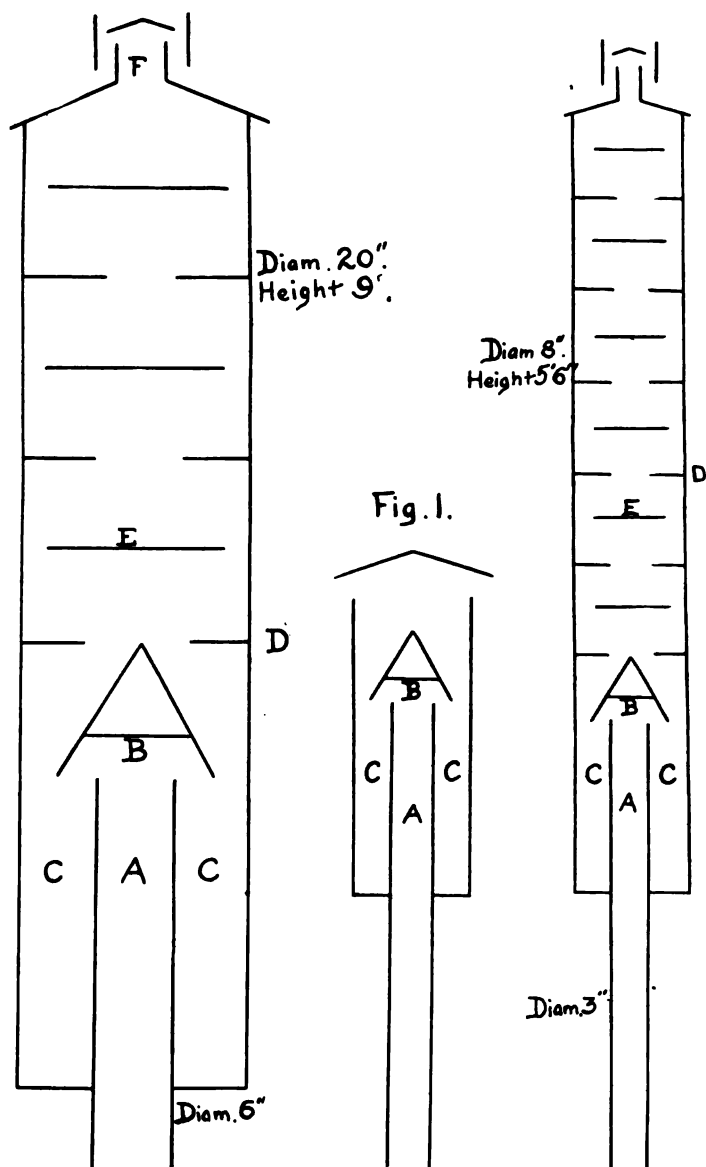
THE SMOKE NUISANCE.

“We wives and housekeepers of Pittsburgh seem to have been born to a life of slavery, with black soot, that comes from our own and neighboring chimneys, our relentless taskmasters. Falling like black snow down into our streets, flying in our faces, soiling our raiment, and entering our homes; it makes black dust-bins of parlor and kitchen alike. It ruins household goods to amounts, which in the aggregate, would be considered an enormous tax upon our people. It causes more aches and pains, from overwork at dusting, scrubbing and lifting, in a vain endeavor to keep clean, than any other enemy of home life. Besides, our physicians tell us, that this nuisance causes more throat and lung diseases than all other causes combined. Is there no remedy for this blot upon cleanliness? It is soot—nothing but black, filthy soot, and why call it ‘smoke nuisance’?”

No doubt the ladies of Pittsburgh will agree that this writer knew what she was talking about. The real nuisance is soot, the product of smoke.

While in search of a remedy for this nuisance some two years since, I was attracted by an often noticed phenomenon, that suggested a possible remedy. We all know that when smoke rises, column-like, into a still atmosphere, the soot and ash, falls to the earth in immediate proximity to the chimney or stack emitting it. It occurred to me, that if one could furnish still-air chambers to our chimneys, for the smoke to discharge its filth into, we might possibly trap the greater portion of the real nuisance—soot and ash. Following up this idea, why not utilize the space, occupied by the brick of the ordinary chimney for a still-air chamber, or soot trap? To test this idea, I constructed a device, on the lines indicated in the drawing Fig. I. A piece of stove-pipe for a furnace, a pipe having a discharge capacity of four square inches and twelve feet high; on the top of which I mounted the device shown in the drawing, constituted my first testing apparatus.





A—Flue. B—Deflector Chamber. C—Trap or Still Air Chamber.
 D—Outside or Wall Carbon Plates. E—Central Carbon Plates. F—Exit.

With the deflector properly adjusted over the top of the flue, I found that all the soot and ash, emitted by the flue, was thrown down into the still-air chamber or soot trap, while the smoke passed up and out at the top. This was, to my mind, an important point gained.

But, in testing my device, I made the discovery that a surprising amount of soot was deposited on the walls of the casing above the deflector and on the under side of the roof. The indications were positive that there was nearly as much carbon carried off, still in combination with the vapor of the smoke, as could, by any possible means, be caught in my still-air chamber or soot trap.

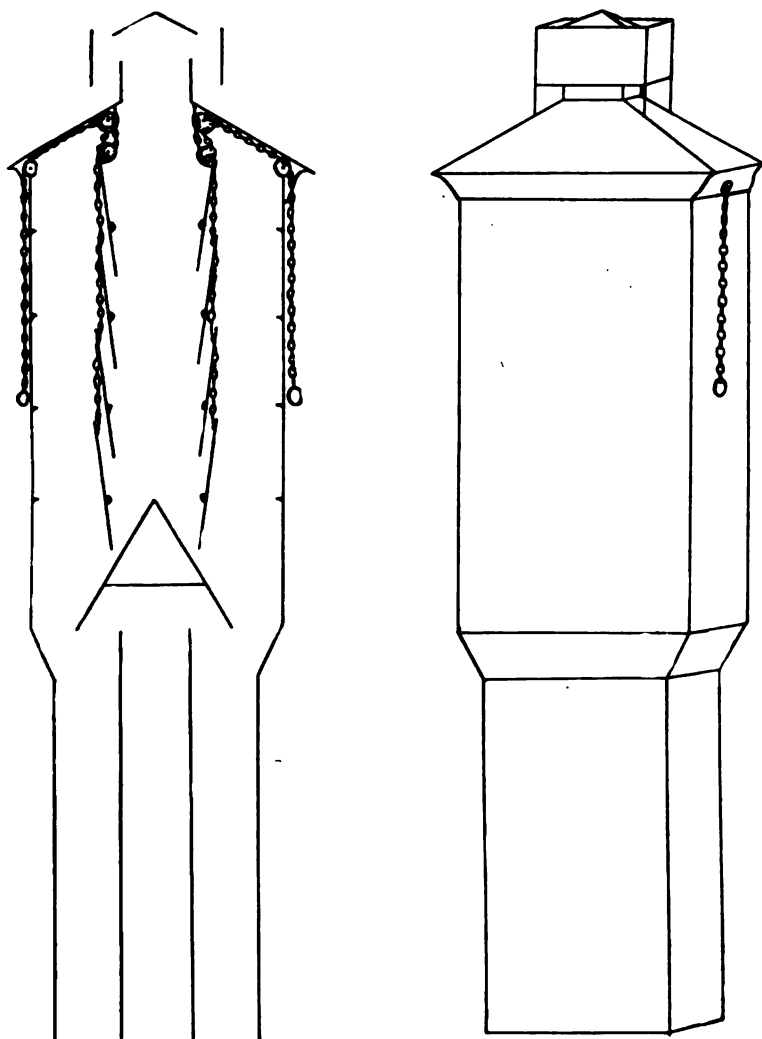
The practical, and seemingly very difficult question presented was—is it possible, in addition to the soot and ash caught in the trap, to extract a desirable amount of the carbon, still in combination with the smoke, after it leaves the chimney? I reconstructed my device numbers of times, and finally obtained results that were in the main satisfactory. While my theory had been that, if I could obtain satisfactory results with a small testing apparatus, the same results would proceed from a device constructed on the largest scale that might be desired, I began to feel that I was by no means sure of it. Would it work on a large flue having a powerful draught? To settle this important question, I built a derrick fifty feet high, to hold my apparatus in position, and to furnish easy access to the working parts of the trap and bleacher.

For a furnace, we use a large, round heating stove. The flue is a six-inch stove pipe fifty feet high. As shown in the drawing, our fifty-foot flue discharges about midway in the trap and bleaching chamber. The trap and chamber enclosed by the outside casing is twenty inches in diameter and ten feet high. As shown in the drawing, above the deflector, is a series of what I call "carbon plates." It will be seen in the drawing, that the first plate above the deflector, extends to the outer wall of the device, and is pierced centrally for the pas-

sage of the smoke. The second plate, is centrally located, with a passage for the smoke extending around it next to the wall. As shown in the drawing, this central and outer passage for the smoke, is alternated, up through the whole series of plates.

A glance at this plate system suggests an infringement upon the column principle, utilized in the distillation of oils. As a matter of fact, it is an adaptation of that principle to the distillation of smoke. It is also an adaptation of the plate system of manufacturing commercial carbon or lampblack, under widely differing conditions of combustion. It hardly need be remarked that in the manufacture of commercial carbon every known means is utilized to prevent the consumption of the carbon freed from the fuel by slow combustion. In this case, we are given the arbitrary problem of extracting the unconsumed carbon from the smoke, fifty or one hundred feet above the fire, and where every known means is used, to consume the carbon in the fuel, for heat-making purposes.

When our device is in operation, the smoke is discharged from the flue, which has a capacity of twenty-eight square inches, up into the chamber of the deflector. From the deflector chamber it is discharged down into the trap or still-air chamber, which has an area eight times greater than that of the flue. In the perfectly still-air of the trap, all the free carbon and ash emitted by the flue, falls readily to the bottom of the trap. From the trap, the smoke rises up around the deflector, through a passage that has three times the discharge area of the flue. When making my first test of this device, I thought that so many dams put in the stream of smoke—represented by the carbon-plates—would tend to hurt the draught of the flue. To overcome this probable difficulty, I started the passage way up out of the still-air chamber, with three times the discharge area of the flue, and diminishing it gradually, discharged the smoke at the final exit through a passage of fifty-six square inches, or just double that of the flue. My



Height from 7 to 14 Feet.

first test developed no injury to the draught. And I found a surprising amount of carbon deposited, mostly on the under side of the plates. The large deposit of soot suggested a corresponding diminution in the density or diffusive power of the smoke. As means to approximate how much the density was reduced in volume, if any, I reduced the final exit, at first, to just the discharge area of the flue, twenty-eight square inches. Still there was no injury to the draught. I then reduced it, a half-inch in diameter at a time, until I reached one-half the diameter of the flue, and one-fourth its discharge area, or seven square inches, before injury to the draught was visible. I then enlarged the exit to ten square inches discharge area, where it remains, with no injury to the draught.

To sum up results of experiments made :

First—The primary undertaking, which was to trap all the soot and ash emitted by chimneys or stacks, in a way that would permit its removal in a cleanly manner, is an unqualified success.

Second—The after undertaking, that of extracting a desirable amount of carbon, still in combination with the vapor when the smoke leaves the mouth of the chimney, is entirely practicable.

Third—If to measure the reduction in the density of the smoke, by the reduction made in the final exit, as compared with the discharge capacity of the flue, be correct (and I have discovered no reason as yet why it is not correct), the reduction in the density or diffusive power of the smoke produced by our testing apparatus, is about two-thirds.

To my understanding, I have by no means reached the limit in the extraction of carbon from smoke, with the testing device represented by Fig. 2. Fig. 3 is a full size drawing of an experimenting device, in which I added plates—twelve in number—when exhaustive distillation manifested itself in the liquifaction of the vapor. The discharge at the exit was a damp, yellowish vapor. The carbon deposited on the upper

plates was wet and pasteey. The liquid that ran down and out at the bottom of the trap was dull yellow in color and extremely offensive. I had no means of testing the draught of the flue, but was led by indications to believe that such injury can be avoided. I was led to believe, also, that while exhaustive distillation is possible, it is not necessary. My present view is that there is a practicable mean between dry and wet distillation, that will accomplish all that can be reasonably desired.

DISCUSSION ON MR. PRESTON'S PAPER.

MR. FISCHER—I would like to ask a question. Has the carbon a commercial value? I think if we could get the quantity of soot collected for a certain quantity of coal burned that it would make the subject more interesting.

MR. PRESTON—I will endeavor to answer the question as intelligently as I can. I would say that the carbon that is in these jars came from fourteen bushels of coal. That was as close an estimate as we could make. I do not think it was over fifteen bushels and certainly it was not less than thirteen. The amount of carbon in this first jar is two and one-half gallons and was trapped in the still-air chamber of the device shown in the drawing. The soot in the second jar was caught on the cooling plates E and measures about twelve quarts. This soot makes good paint. Mr. J. W. Ball said it was the finest tinting carbon he ever saw—dries quickly and has a commercial value. This was taken out from a chimney fifty feet high. The third jar contains cinders and half burned carbon sifted out of a trap and measures about two quarts.

MR. WALKER—Was that taken out of an apparatus equal in capacity to the ordinary heating stove?

MR. PRESTON—It was.

PRESIDENT—You mean to say it has a commercial value?

MR. PRESTON—My information is that it has if it is nicely cleaned; and I can make a machine that will clean it. I can demonstrate the work done, better with a model which I have

here. These plates when the device is doing its work are all lying down. The carbon does not stick on the upper side of the plates, but to the under side, and when ripe falls or drops on the upper side of the next plate, from whence it is dumped into the trap as occasion requires.

MR. FLANNIGAN—My ideas are rather cloudy as to the relative size of the apparatus. Suppose the stack to be 150 feet high and seven or eight feet in diameter, what would be the relative size of the still-air chamber and the required plates?

MR. PRESTON—It depends how large the chimney is; but an ordinary house chimney need not be over ten feet high.

MR. FLANNIGAN—The point I want to bring out is, if you put the trap on such a tall chimney would it not be a very difficult matter to sustain it?

MR. PRESTON—Builders of stacks tell me that it can be supported very easily by a gas pipe or angle iron tower built up from the ground.

There has been a supreme effort made to eradicate the soot from large stacks and chimneys; but the common cook stove throws out more soot and dirt per ton of coal burned, by far, than does the tall chimney. The real nuisance of smoke—soot deposits—comes from your lazy drafts. This device of mine is applicable to house chimneys as well as tall chimneys and stacks. I know that I can take every particle of dust out of your smoke.

✓ THE ECONOMICAL COMBUSTION OF FUEL AND THE PREVENTION OF SMOKE.

BY ROBERT LOUDON WALKER.

I have here several drawings, from which I will endeavor to explain what I consider to be practical methods of burning bituminous coal.

Before I begin, I would like to make an assertion, the

truth of which I have demonstrated time and again: "*Coal can be burned without smoke!*"

When I say this I mean practically "without smoke," because it would be impossible to absolutely stop all the smoke all the time, and there is a point in the prevention of smoke beyond which economy ceases.

However, my methods have resulted in stopping ninety to ninety-seven (90 to 97 %) per cent. of it, and when you consider that this means a practically smokeless chimney for about 57 minutes per hour, you can readily see the gain in cleanliness. Whether this gain is accompanied by a corresponding increase in economy, I shall show later.

I desire to say here that the method of which I am speaking is very simple indeed; that the idea is a basic one as applied to perfect combustion of fuels. It is applicable to all forms of furnaces, such as steam generators, heating and puddling furnaces, garbage furnaces, and steam locomotives, with such modifications in the construction as will fit it to local conditions, and particular cases, always preserving, however, this basic feature of the method.

This method of furnace building is simple, scientific, and practical. It is the result of many years of study, experiment and practice. It is one which reason perceives, experiment verifies, and experience confirms.

In the first place, I think everyone will concede that, as a rule, there is something lacking in the present practice of furnace building. This is evidenced by smoke pouring from factory and building chimneys everywhere in this district, an unclean and expensive tribute to errors in the furnace.

It was to locate these errors, and avoid this waste, that I took up the study of perfect combustion with results which speak for themselves.

Experiments have been made which show that, theoretically, it requires about 150 cubic feet of air, at a temperature

of 60 to 65 degrees, to consume one pound of average bituminous coal, say a coal containing about 70 to 80 per cent. of carbon or coke.

This assumption, however, is entirely misleading, as you will notice the temperature of air is allowed at 60 to 65 degrees. This is not practicable, and does not take into account the enormous expansion of volume due to higher temperatures. This expansion is shown approximately as follows :

Air required at 60 to 65 degrees, about 150 cu. ft.

Air required at 100 degrees, about . . . 155 cu. ft.

Air required at 600 degrees, about . . . 325 cu. ft.

Air required at 1000 degrees, about . . . 450 cu. ft.

These approximate figures, however, also neglect the considerable portion of oxygen which passes off uncombined, due to defective fire-box construction, or flues. This loss varies largely, but as a rule, it means that even a larger volume of air than that given above, should be figured upon.

This, then, is one of the prolific sources of trouble, mostly found in boiler furnaces, where the temperature of the air beneath grate-bars, or of the combustion chamber itself, is not so high as in heating, puddling and other furnaces. The present methods of furnace building do not figure on a sufficient supply of air at the proper place. Witness the effect of a blast upon the fires for a confirmation of this assertion.

Another source of trouble and loss is the immense amount of heat absorbed by the air, in raising it to the temperature of the burning gases.

The problem resolved itself into two features:

First. How to supply a larger portion of air, without resorting to forced draft, as ordinarily introduced, and other methods now in use.

Second. How to raise the temperature of this larger amount of air, without too great a loss of heat in the combustion chamber.

THE ECONOMICAL COMBUSTION OF FUEL, ETC.

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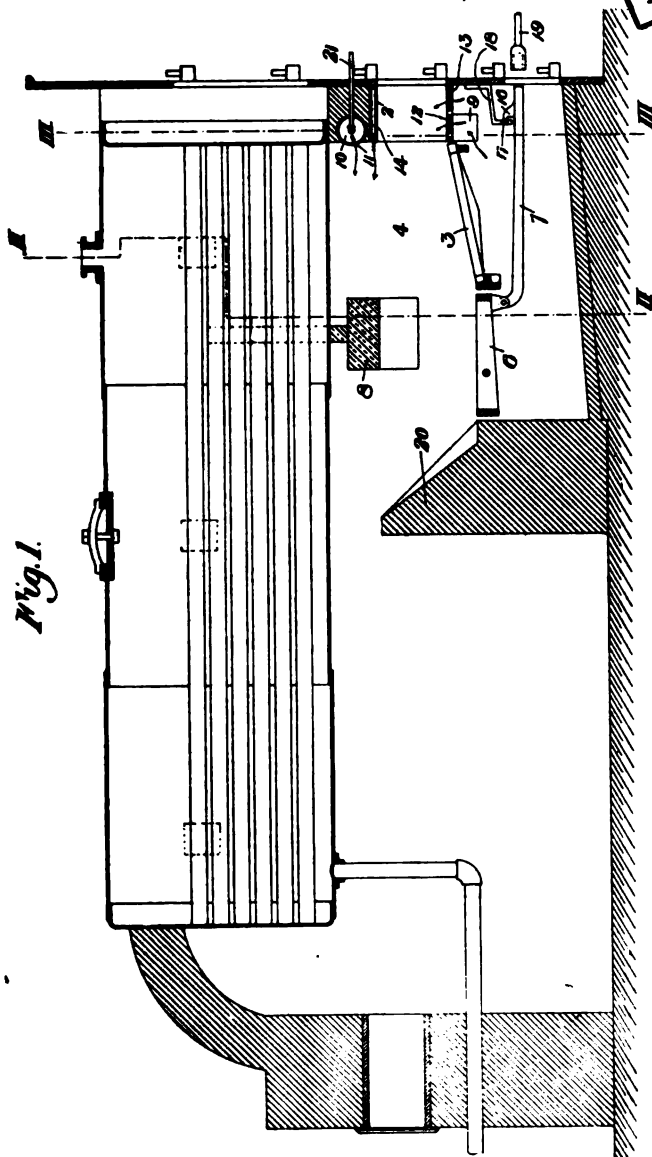
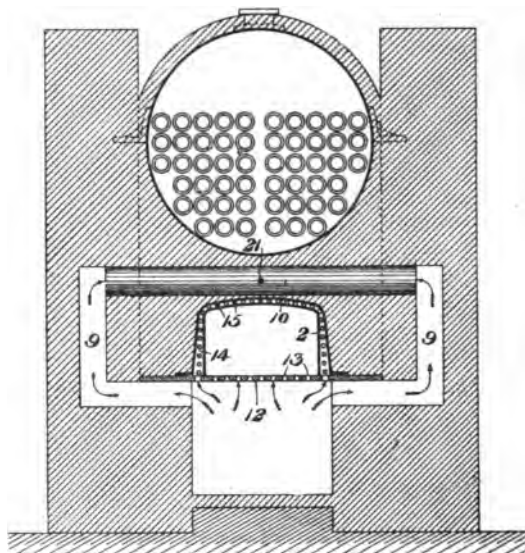


Fig. 3.

With these points in view, I went to work, and evolved a plan of taking the air through holes in the ash-pit, or elsewhere nearby, and carrying it, by means of ducts, to a point above the fire, and then by means of a deflector-arch, introducing the now heated air into the process of combustion, as shown in the drawings above.

There was another very important point to be considered, and that was the point at which to introduce this air. This was arrived at by a study of the process of combustion, in its effect upon the fuel itself. The process of combustion, or of converting fuel into heat, is two-fold.

First. The distillation of the volatile matters, the hydrocarbons, which are the flame and smoke-making portions of the coal. This portion of the process must be completed, or nearly so, before the next operation begins, which is,

Second. The consumption of the carbonaceous portion, or as commonly known, the coke.

In the manufacture of coal-gas, and coke, the processes of combustion are stopped at the end of the first operation. In some methods of making water-gas, the process is carried out to a finish, as in the steam generator, in heating iron and steel, or other metals.

These are well known facts, you will say, *but I contend that not enough attention has been paid to this very point. It has, apparently, been so simple that it has escaped the notice it deserves.*

For instance, taking one pound of average bituminous coal, we find that about 150 cubic feet of atmospheric air, at 60 to 65 degrees, is chemically required for its combustion. This volume, as I have stated, becomes very greatly augmented by its rise in temperature, but as the proportions will hold throughout a considerable range, I will use these figures for illustration.

Of 150 cubic feet of air introduced into the fire-box, there is required:

For combination with the volatile matters, about 45 cubic feet.

For combination with the carbonaceous portion, about 105 cubic feet.

This proportion is further illustrated by the following diagram:

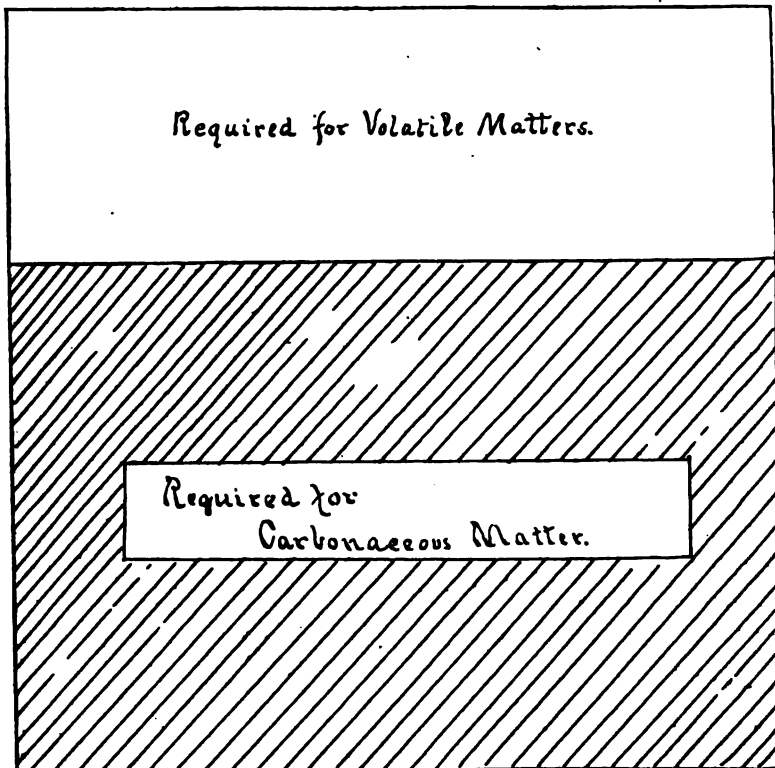
It would therefore seem plausible that during the process of combustion, we should introduce, through the usual channels, sufficient air to distill out the volatile matters, and turn our fuel into coke.

This process has consumed about 25 to 30 per cent. of our fuel, requiring about 30 per cent. of the total air.

We have now remaining about 70 to 75 per cent., by weight, of our fuel, requiring *twice the amount of air*, by volume, that our first process did.

I therefore came to the conclusion that at this point in the process should be introduced the additional supply of air, at

Total Volume Air Required.



as high a temperature as possible, to economically finish the process.

It was therefore determined to locate the deflector-arch at about that point in the fire-box where the distilling process ceases, or almost so, and the consumption of the carbon begins!

This gentlemen, is my theory, and the basis of my patents in a nutshell:

I burn the fuel to coke in the front part of the fire-box, supplying the required portion of air for this process. The coke is now pushed back to the rear, *a larger supply of air given to it*, and green fuel put on the front again, the process being carried on *ad infinitum*.

The smoke and gases generated in the distillation are compelled to pass over the incandescent coke fire, and are consumed, adding to the heat of combustion, the cleanliness of the stack, and the economy of the process!

Now, gentlemen, I have been dealing thus far with theory. With your kind permission, I will speak of facts, and demonstrate results as applied to several forms of furnaces, for different purposes.

STEAM GENERATORS AND BOILERS.

Gain in Temperature.—By pyrometer tests, I have taken the temperature of the inflowing air at the point where it is deflected into the fire-box. The instrument showed over 650 degrees F. This, gentlemen, with a temperature in the firing-room of 100 degrees, was a clear gain of 550 degrees, or over, constantly! You can readily see what this would amount to in heat units, in a day or year.

Smoke Prevention.—You will also please observe, that by introducing air at this high temperature, at a point just in the rear of where the largest amount of smoke is generated, it will not require much additional heat to turn the gases into a clear white flame, almost smokeless. This very thing I have done, and am now doing in a number of places.

Many tests for smoke prevention have been made by perfectly competent engineers of this city, some of them members of this Society, and the results have never been lower than 90 per cent., and as high as 97 per cent. I have copies of such tests in my possession, kindly furnished by the people in whose interest tests were made. I am perfectly willing to show the tests or the stacks themselves.

Some of these tests resulted as follows :

Test at "B" boilers	92 %
Test at "C. S." boilers	94 %
Test at "H" boilers	97 %
Test at "Mill C" boilers	95 %
Test at "Mill J" boilers	96 %

If for no other reason than this, owners of boilers and furnaces should be willing to correct the faults in their furnaces. The gain in cleanliness, the many thousands spent in repainting and cleaning properties defiled by black smoke and soot, would more than counter-balance the cost, to say nothing of the increased economy of operation.

Economy.—I have just received from Chicago, where I have installed a number of furnaces, a statement that shows a saving of 24.4 per cent. per year, on a trial extending over two years. This statement, now in my possession, is an official one, as made to the board of directors, and there is no doubt of the results.

In addition to the saving in fuel, the stacks were clean ninety-six per cent. of the time. This same percentage, obtained on all the smoky stacks of this city, would reduce the smoke question to a point where it would no longer be called "a nuisance."

Some other tests, most of them local, and easily verified, ran as follows :

(Water evaporated per lb. combustible, from and at 212 degrees)	Setting.	
	Common.	Walker.
At Mill C-1, two 2-flue boilers, 4 weeks.....	7.55	9.48
At Mill C-2, two flue boilers.....	(No test)	9.91
At Mill O, two flue boilers.....	do	9.57
At Mill C-1', two flue boilers.....	do	9.01
At Mill C-8, two flue boilers.....	do	10.02
At Mill J, six flue boilers.....	9.12	10.89

These tests are all made on common flue boilers; on tubular boilers, the results are much greater, as copies of tests show.

On common two-flue types, my practice has been to guarantee 20 per cent. saving, expressed either in additional power, or the same power with less consumption of fuel per

horse-power, At Mill "J" tests were made for "economy" and "capacity," with the following results:

"MILL J."	Common.	Walker.	
		Capacity.	Economy.
Evaporation per lb. combustible from and at 212 degrees.....	9.12	9.72	10.89
Lbs coal per H. P. per hour.....	4.03	3.04	2.46
Per cent. over rated capacity.....	.....	163 per cent.	.....

Repairs.—I have been surprised to find that with this setting the life of brick-work seems to be prolonged somewhat. I can only attribute this to the fact that the air in the ducts is constantly absorbing heat from the fire-brick, and keeping their temperature below what it is ordinarily.

MR. GOW—I think, Mr. Chairman, that the prevalent impression as to the amount of carbon which passes off as black smoke is erroneous. The unconsumed carbon passing out of the smokiest chimney in the city of Pittsburg, does not amount to two per cent. of the coal fired. In fact when a chimney is smoking to the extent of one per cent. of carbon in the coal, it is an exceedingly smoky chimney and one-half of one per cent. is very bad. Of course, I mean by smoke in this connection, the black particles of unconsumed carbon and not the unconsumed CO and the products of combustion. The bituminous coal of this region requires about 150 cubic feet of air to the pound, theoretically, to be consumed. In practice this amount would prove insufficient, the furnace would smoke badly, and the waste of fuel would be considerable. 250 feet to the pound is nearer to existing practice than 150. In a recent efficiency trial made by very competent men, where the results attained were the best I know of, 180 to 200 cubic feet were supplied per pound of coal.

Because a chimney is smoking it does not follow that the boiler efficiency is not good. In fact, I am inclined to think

that the highest efficiency would be attained when the chimney is not entirely free from smoke. The reason is simple enough that the amount of heat saved by the combustion of that $\frac{1}{2}$ to 1 per cent. of smoke black, would be more than lost by the heat carried away in the increased volume of products of combustion due to the large excess of air required to get the result.

I know that this would be popularly considered great heresy, but it still is good engineering.

MR. WALKER—Of course, Mr. Gow is referring now to *common* settings, within his own experience, and I dare say he is right about the inadvisability of trying to run a smokeless stack with such settings, which I am here endeavoring to prove are not designed to do so. But results have proven that my furnaces will prevent this waste, without any loss in economy. In many instances, and in every case, I have given from 20 per cent. to 30 per cent. of saving.

I applied my method to two boilers and saved 85 bushels of coal in 12 hours. The smoke test was made by one of the engineers from City Hall, and showed 92 per cent. efficiency.

In another instance, on a battery of boilers, the saving was one gondola car of coal per day.

MR. CAMP—In what way does this air come in?

MR. WALKER—It comes in through holes in side walls, then through ducts to a point near to the deflector arch, which it strikes and is diffused into the fire.

We have Mr. Brennan with us this evening. He has had all the smoke consumers tried. I think it would be advisable if he would tell us whether there is any saving of coal when smoke is stopped.

MR. BRENNAN—I prefer to listen to the information this evening, as I am a stranger. However, the furnaces are doing very well.

PUDDLING AND HEATING FURNACES.

MR. WALKER—On both of these types I find my work somewhat handicapped by a woful lack of method in construction.

There does not seem to be any fixed proportion between grate surface, and the work desired from a furnace, or any relation between grate surface and area at bridge wall.

The stacks are frequently out of proportion to the rest of the furnace; many stacks, built originally for natural gas, are now entirely too small, the mills having returned to the use of coal. I have found that taking a number of the same style of furnaces in the same mill, there will be a variation of as much as 20 per cent. in the proportions. As I have not had anything to do with any part of the furnace other than the fire-box, this lack of uniform proportion makes it harder to show uniform results.

Many firms do not know, even approximately, how much coal is burned to puddle a ton of iron, or heat a ton of metal. I understand that it usually required 30 to 33 bushels of coal in this district to puddle a ton of iron. I have repeatedly produced a pound and one-half of puddled iron per pound of coal. This economy, I attribute to the burning of the gases in the furnace instead of in the stacks, as is done in many cases.

	Common.	Walker.
Test at Mill "X," two turns per day: Pounds iron per pounds coal.....	.89	1.12
Pounds coal per pounds iron.....	1.11	.89
Test at Mill "M," 3 turns. Pounds iron per pounds coal.....	1.20	1.52
Second test.....		1.50
Test at Mill "S".....		1.50

MR. CROOKER—May I ask if you use a top blast?

MR. WALKER—Yes, sir.

On heating furnaces I have shown some very good results, but no tests by weight have been made. The only gauge I have is the amount of work done by the same furnaces before and after changing to my construction.

At mill "K," the output of two heating furnaces was increased 100 per cent., and the manager stated the saving in fuel to be over 50 per cent.

At mill "J" the increase in capacity was almost 50 per cent. Two weeks output before I changed the fire-box was 602 gross tons consuming, 108.68 net tons of coal.

Two weeks after the change of fire-box 709.50 gross tons iron, with 102.75 of coal.

At works "C-N" the material was heated more rapidly, but owing to the nature of the work, no capacity test could be made.

In all these tests the heat was steady and uniform, and the waste of metal by oxidization was lessened considerably. This is probably due to a lesser amount of uncombined oxygen in the gases.

The percentage of smoke prevention was high in every case, some furnaces running smokeless all the time, even after firing.

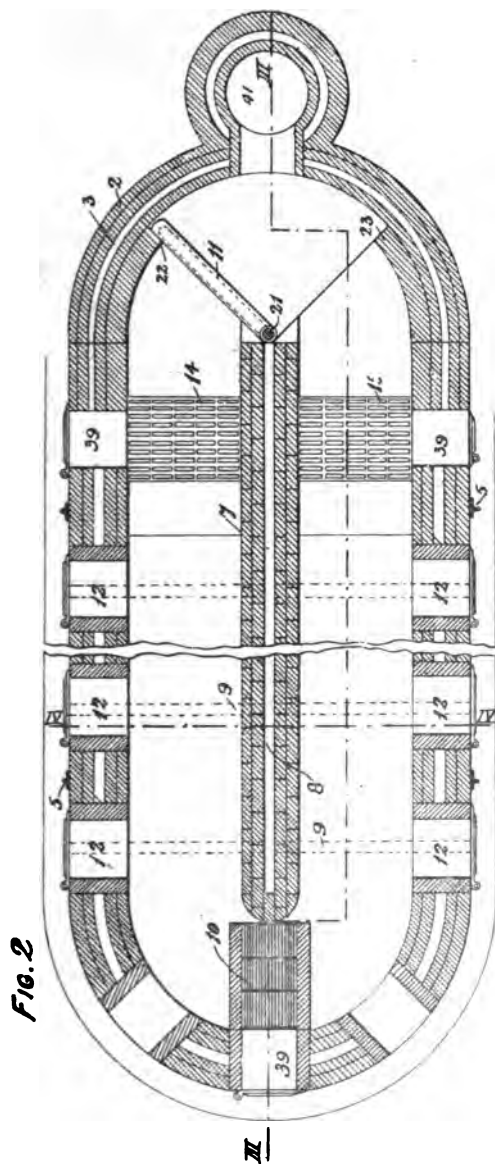
GARBAGE FURNACE.

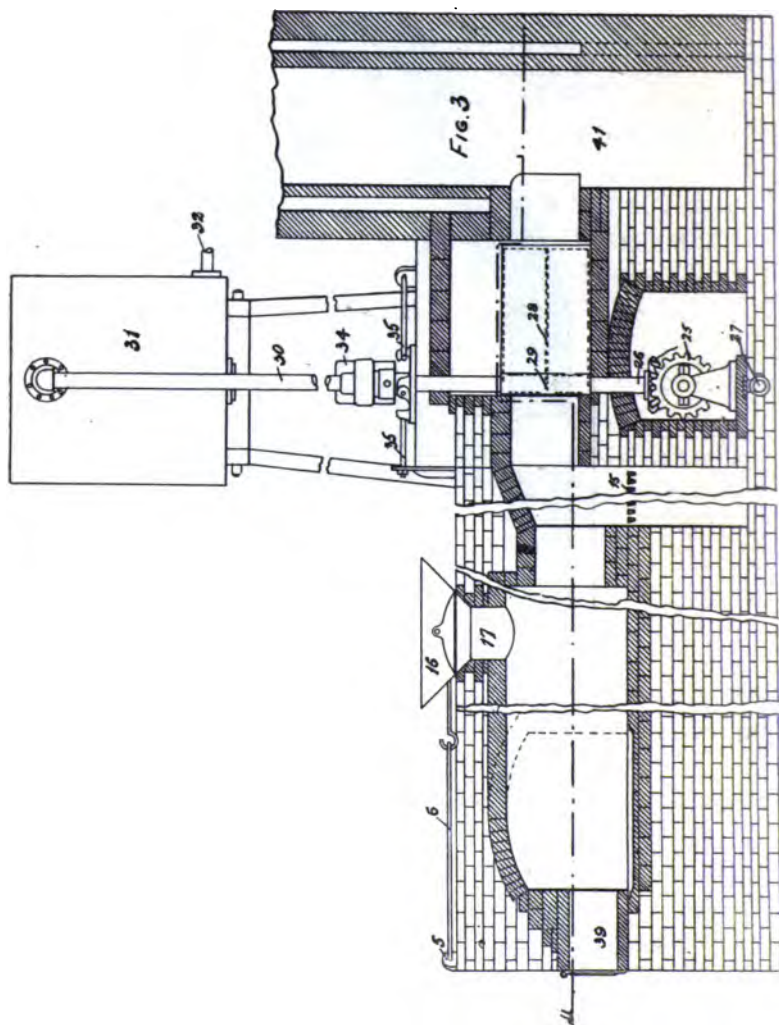
The United States Congress recently passed a law forbidding the dumping of garbage or refuse into any river or harbor. This law, which is recognized as a wise sanitary measure concerning the public health, confines the disposal of garbage to one method, *i. e.*, its destruction by heat.

The principal objection to this method has been the noxious odors arising from the process. This nuisance has been augmented by attempts to recover the oily matters (about 3 %) present in all garbage, by boiling or distillation. This necessarily generates odors which are very unpleasant and unhealthy. Sanitation demands a better method of destruction.

Here are drawings of a furnace for cremating garbage, designed particularly with reference to elimination of bad odors. We all know about our local troubles in this respect.

In this furnace we have a horse-shoe form, and a water damper built on the same principle as the one in my locomotive engine.





The process is designed to be continuous, first on one side and then on the other, the direction of the draft being changed by the mechanism and the damper.

The fire-boxes are built on the same plan as all the other furnaces. The gases are compelled to pass over an incandescent fire on their way to the stack, and are there completely

consumed. All gases will burn with proper sufficiency of oxygen.

I believe it will also be possible to so connect this furnace with the local sewers that much of the dangerous and unhealthy sewer gas will be withdrawn and burned.

Another feature of this furnace is that the heat from the gases can be utilized in making steam, which can be converted to electricity.

If a city the size of Pittsburg were equipped with six or seven such furnaces, in convenient parts of the city, not only could garbage be destroyed without odor, sewers ventilated, but electricity be generated for the use of the city.

I figure that every furnace could supply sufficient heat to operate a 200 horse-power boiler. This would yield upwards of 200 arc lights. These street lights now cost the city \$96 per year per light. You can readily figure that this end of the business could be made profitable, and easily over-balance the profit obtained from extraction of the grease, and with less annoyance to the neighborhood. It is needless to say that this furnace, in addition to being odorless, is also smokeless.

MR. GOW—Has a plant on this general plan been constructed?

MR. WALKER—No, sir. But experiments I made have demonstrated that garbage odors, passed over an incandescent fire, lose their odors.

MR. SCHELLENBERG—We should speak a good word for our old member, Mr. Walker, that his furnace, regularly tended, will consume the coal fully and leave only ashes as waste through the grates. I point out, too, that we have corroboration of the assertion that the waste of the carbon from a smoking chimney will be less than one per cent. It is plain that the amount of soot, as the complete collection in the jars shown by Mr. Preston, of five and one-half gallons from the consumption of thirteen to fourteen bushels of coal—equal to 1,000 pounds—is not over one-half of one per cent.

MR. WALKER—We all know that the furnaces are not built as they should be. I have been connected in one way or another with this business for thirty-five years, trying to stop the smoke nuisance. I can teach any man to work the fires on my furnace in three hours.

I have heard it said that good iron cannot be made without smoke. I failed to notice that Pittsburg's prestige suffered much during the time when all the mills used natural gas, as some of them do now.

I think the elimination of the smoke nuisance would amount to a saving of almost a million of dollars a year in cleanliness, health and economy.

A SPARKLESS AND SMOKELESS LOCOMOTIVE!

I consider this achievement one of my best. Some years ago a test locomotive was built by me, and run for many months, without sparks or smoke. I was unable to follow the matter up at that time, for financial reasons.

A test made on the Illinois Central, with Illinois coal, showed an evaporation of 8.25 pounds of water per pound of coal. The test was over a stretch of 540 miles, between Chicago and Champaign. The Illinois Central put against me what they considered their best engine. They showed an evaporation of 4.50 lbs. of water, a difference of 3.75 lbs. of water per lb. of coal in favor of my engine.

This machine ran for many months without a cent for repairs. I have recently patented some important improvements, the result of later experiences. It will now be impossible for the damper, which was the only source of weakness, to get out of order. The damper is now turned by steam, and much simplified.

No extra work for Engineer.—The Engineer has nothing to do with this device. The fireman turns the damper, by simply turning, one-quarter turn, the handle of the cock on top of the boiler (See drawing Fig. 1). This changes the current from right to left or *vice versa*. As soon as the damper is turned and in place, a new charge of coal is put on.

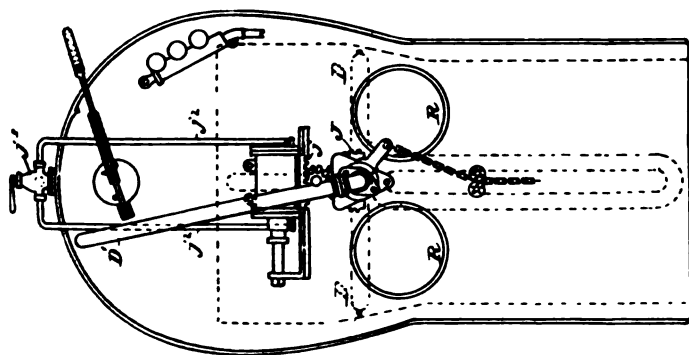


Fig. 1.

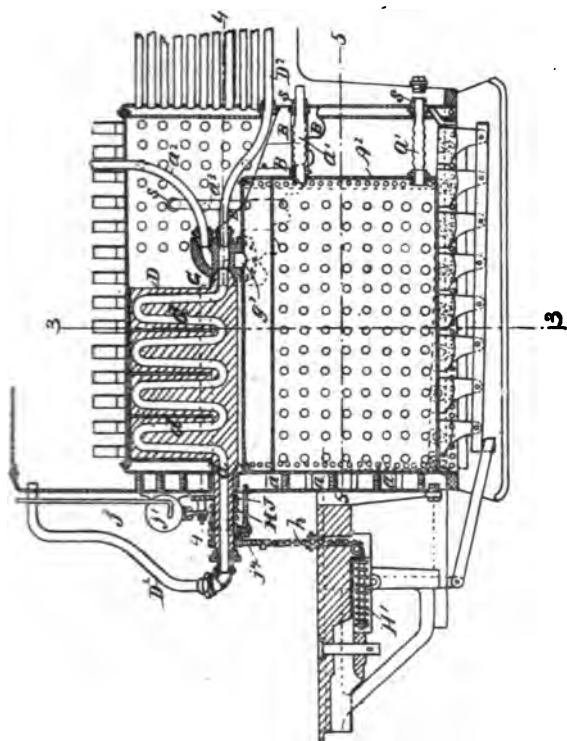


Fig. 2.

Saving in Fuel.—I understand 200 miles is considered a day's run for a locomotive in passenger service, and fifty pounds of coal, the average amount of coal burned per mile. A locomotive averages therefore a consumption of 10,000 lbs. of coal per day.

My locomotive would save at least one-third of this coal. On the 30,000 locomotives of this country, this would be enormous.

Steaming Capacity.—The additional heating surface in the furnace, namely the center water-leg, and damper, are exposed at all times, to an intense heat, with an unfailing supply of water. There is no reason why, with Pittsburg coal, this locomotive should not give nine to nine and a half pounds of evaporation.

Saving Tubes and Flues.—Since no sparks come in contact with the ends of the flues there is nothing to wear them away, and thus cause them to leak. All sparks are burnt up in the lower part of the fire-box, and there is no need to have an extension front or a netting in the stack, as there are no sparks.

Saving Road-bed.—Where stone ballast is used it is well-known that the cinders fill up the spaces between the stones, and holding the moisture cause the sleepers to rot.

With a new locomotive the cost to apply this method would be about \$300 additional. Where this would be done in the shops, necessary tools and knowledge would cut this down.

The absence of sparks would eliminate a fruitful cause of forest fires, which cost thousands of dollars annually.

DESCRIPTION OF CUTS :

Figure 1.—Elevation showing doors, lever and steam cylinder for turning damper K.

J—Is a cock connected with steam space of boiler, and each end of cylinder *J 1* by pipes *J 1* and 2. When the steam is passing to the right-hand end of the cylinder, the left-hand pipe is exhausting and *vice versa*. This change is made by turning the handle of the cock (*J 2*) one-quarter turn, and this

is done by the fireman. It is put behind the steam gauge in practice.

D—Discharge pipe from damper to steam space. This pipe, which carries steam at the same time water, and falling on the crown sheet, will be the means of preventing damage in case of low water in boiler.

J 4—Gland to hold the thrust of spring on damper spindle and is held in place by three 1-inch studs screwed into boiler.

Figure 2.—Cross section through furnace, showing water-leg (*J*), arch (*BB*), of fire-brick, and damper (*D*).

A—Are brace pipes connected with water space.

The corrugated fire-brick arches break up sparks.

(*S S*)—Grate surface.

There has lately been considerable talk as to what the electric engine was going to do to the steam machine. Let us consider for a moment the cause for alarm.

The electric engine cannot be made heavier than the present steam locomotives, because the capacity of bridges are tested to their full capacity to-day. The traction would be the same, according to their weight. Prepare both equally to meet the atmospheric pressure, and I know no reason why the steam engine cannot run as fast as the electric engine.

Great stress is put upon being able to generate more steam with stationary boilers than with the locomotive boiler, as it is to-day. The average evaporation in stationary boilers is not over 8 pounds per pound of coal.

Losses from the boiler to the engine, from engine to dynamo, and dynamo to motors, especially on long lines, would bring down the available power very materially. A locomotive built on the plan I have outlined, giving 8.5 pounds of evaporation, would, I believe, put the electric competition out of the race, considering the interest on investment, etc.

On motion the meeting adjourned at 10:35 P. M. and the members partook of a lunch which had been provided by the Reception Committee.

REGINALD A FESSENDEN,
Secretary.

MEETING OF THE CHEMICAL SECTION.

PITTSBURG, PA., June 23, 1898.

The regular monthly meeting of the Chemical Section was held June 23, 1898.

Chairman, J. O. Handy.

Attendance, 11.

The minutes of the last regular meeting were read and approved. A letter from the secretary of the Engineers' Society in regard to the discontinuance of the *Chemiker Zeitung*, and *Berg u Huttenmaennische Zeitung* was read.

On motion of Dr. Stahl it was resolved that the Section requests the Board of Direction to reconsider its action in discontinuing the *Chemiker Zeitung*, as it is often consulted by members of the Chemical Section.

Dr. Phillips, for the literature committee, read abstracts of a number of articles on recent chemical discoveries. In connection with Ramsay's discovery of Krypton he showed a sparking tube by which Argon could be obtained from the atmosphere. An interesting discussion of the points brought out in the abstracts followed.

Mr. Handy read the following notice taken from the "Manufacturer" of June 18.

The Belgian government offers a prize of 50,000 francs to the inventor of a paste for matches which shall be free from white phosphorus and which will ignite on a cloth or any other surface. The competition to be international and to remain open until January 1, 1899. Communications on the subject may be addressed to M. Woeste, No. 2 Rue Laterale, Brussels.

Mr. A. G. McKenna read a paper on The Analysis of Ferro-Tungsten.

ANALYSIS OF FERRO-TUNGSTEN.

With many iron alloys the question of obtaining complete decomposition and solution gives the analyst much trouble. Sodium peroxide is one of the most efficient means of bringing about decomposition of substances which are refractory towards the reagents generally used.

There is, however, one drawback to its use; the action in the molten condition is so energetic that crucibles of whatever material composed are attacked, and consequently the analysis is complicated by the presence of salts derived from the metal of the crucible. Nickel crucibles have been generally used for peroxide fusions, but nickel salts are often very annoying in an analysis. The writer has found that copper crucibles resist the action of the peroxide quite as well as do those of nickel, and as copper salts are much less troublesome in most analysis it is often advisable to use copper crucibles for the fusion.

In the analysis of ferro-tungsten the decomposition can be brought about very readily by the use of peroxide. If only the common constituents of ferro-tungsten, *i. e.*, iron, tungsten silicon, carbon and traces of manganese are to be determined, the following process will answer:

Weigh one-half gram of the finely ground sample, and mix thoroughly with three grams of sodium peroxide in a copper crucible. It is necessary to use a weighed amount of peroxide and correct for the small amounts of silica and iron which are always present. Fuse for about one minute at a dull red heat over a Bunsen burner, holding the crucible in a pair of tongs and agitating the fusion slightly in order to prevent the metal from gathering in a lump at the bottom of the crucible, where it would not be acted on so readily. When cool place the crucible and contents in an evaporating dish with watch glass cover and leach out the fusion with hot water; remove the crucible, washing it free from any adhering

particles, add a few cubic centimeters of alcohol and heat to render all manganese insoluble, filter with suction, washing well with hot water.

If the decomposition is complete all the tungsten will be in the filtrate and all the iron, manganese and copper on the paper. Part of the silica will be with the residue and part in the filtrate. Transfer the filtrate to a six-inch evaporating dish, acidify with hydrochloric acid and evaporate to dryness on hot plate to render tungstic acid and silica insoluble; take up in 15 cubic centimeters of hydrochloric acid and evaporate to dryness again to insure insolubility of last traces of tungsten; take up with 15 cubic centimeters of hydrochloric acid, add 100 cubic centimeters of water, boil for a few minutes, filter with suction, washing with dilute nitric acid (1 acid to 10 water.) Water alone must not be used or the precipitate will run through the paper. It is always well to test the filtrate for tungsten by again evaporating to dryness.

While the filtrate has been evaporating dissolve the iron, copper and silica residue on the paper in hot dilute nitric acid, and evaporate to dryness to render silica insoluble. Take up in hydrochloric acid and water, filter through the filter on which is the tungstic acid, washing again with dilute nitric acid. Ignite and weigh in a weighed crucible, as $\text{WO}_3 + \text{SiO}_2$, add one-half cubic centimeter of sulphuric acid and about 5 cubic centimeters of hydrofluoric acid, evaporate slowly to dryness in the crucible, then ignite strongly and weigh; the loss is SiO_2 and is calculated to silicon.

The residue left in the crucible is tungstic acid containing 79.3% tungsten, which is calculated to the metal.

In order to clean the crucible it is necessary to fuse with about two grams of sodium carbonate; this fusion should be leached out in hot water and examined for any impurities. If nothing but tungstic acid was present a perfectly clear, colorless solution will be obtained.

To the solution containing the iron and manganese add

ammonia in slight excess and boil, filter with suction, washing with hot water; redissolve in dilute nitric acid, and reprecipitate with ammonia; filter and wash as before, ignite and weigh as ferric oxide. It is well to dissolve this precipitate and titrate for iron to check the possible presence of alumina. To the combined filtrates from the iron precipitations add bromine, filter off MnO_2 , dissolve in hydrochloric acid, add excess of ammonium phosphate, make ammoniacal, boil, filter, ignite and weigh as manganese pyrophosphate.

The above method answers very well when the ferro-tungsten contains no appreciable amounts of other elements, but the analyst must constantly bear in mind that ferro-tungstens are not unlikely to contain other metals; for instance, chromium and aluminum.

In case these are present the chromium will all go into the soluble part of the fusion together with most of the aluminum. After the tungsten has been separated by the evaporation to dryness, the chromium and aluminum may be precipitated together as hydrates by ammonia, ignited and weighed together, then dissolved by treating in a small flask with concentrated nitric acid and four or five grams of chlorate of potassium. The chromium all goes into solution as chromate. By adding ammonia in very slight excess the alumina can be separated, filtered off, ignited and weighed. The chromium in the filtrate may be titrated after the addition of nitric acid by means of ferrous sulphate and permanganate, or may be reduced in the acid solution by peroxide and precipitated and weighed as chromic oxide. It must be remembered that if aluminum is found part of it will be with the iron precipitate and must be allowed for.

Carbon in ferro-tungstens, as in most of the iron alloys which are not attacked by copper salts, is most easily determined by direct fusion with peroxide of sodium. The carbon is all converted into carbon dioxide and held by the soda. It can then be determined by evolution with acid and

absorption in barium hydrate. It is, of course, necessary to allow for the carbon dioxide in the peroxide, which generally amounts to about one per cent., and to avoid getting appreciable amounts of carbon dioxide into the solution from the air.

By using a tall, narrow, covered crucible, however, the error can be kept very small.

After a brief discussion of the paper the Section adjourned at 10:20 P. M.

A. G. McKENNA,
Secretary C. S.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Society's house, 410 Penn Ave., September 20th, 1898. The meeting was called to order at 8.30 P. M., the second Vice President, Mr. Lewis, in the chair, and thirty-four members and visitors present.

The minutes of the previous meeting were read and approved.

For the Board of Directors, the following applicants were reported as passed:

RICHARD G. G. MOLDENKE, Metallurgical Engineer for McConway & Torley Co.

JOSEPH S. SEAMAN, Manufacturer of Rolls, Seaman, Sleeth & Black.

For the Library Committee, Mr. Albree made a report of progress, and recommended an appropriation of \$50.00 for indexing and putting in place the books. Referred to Board.

The paper for the evening was then delivered by the author, R. A. Fessenden, and after some discussion the meeting adjourned, 9.45 P. M.

R. A. FESSENDEN, *Secretary*.

✓ HOW TO PREDETERMINE THE TENSILE STRENGTH,
RIGIDITY, YOUNG'S MODULUS, AND ELEC-
TRICAL CONDUCTIVITY OF METALS
AND ALLOYS.

BY REGINALD A. FESSENDEN.

(ABSTRACT.)

The author stated that, as the members were aware, the Committee on Papers had succeeded in getting the promise of a series of papers on the manufacture of Iron and Steel, from the digging up of the ore to the finished products, by the most eminent authorities in the world on this subject. The first paper, however, could not be ready for the present meeting, and he had been selected to fill the gap.

It had occurred to him that a paper showing *why* iron is such an important material, *why* it has its great tensile strength and rigidity, and why carbon and other materials produce the effects they do, when combined with it, might be of interest.

It was then shown that the sizes of the atoms might be calculated in various ways, all agreeing fairly closely, and it was pointed out that by determining the vapor pressure and surface tension of mercury the size of the atoms could be determined with approximately the same accuracy as most atomic weights.

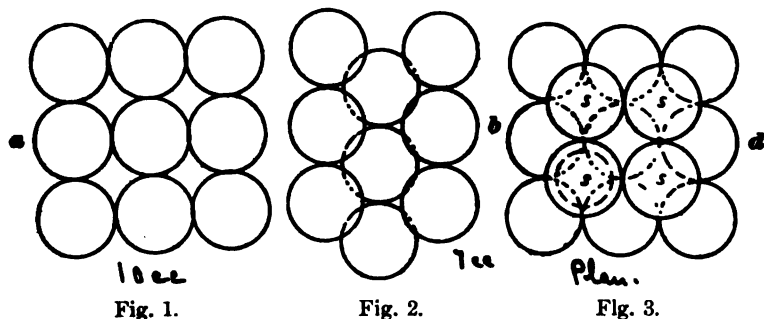
That at ordinary temperatures the atoms of solids were nearly touching each other; that practically all metals expand only about 2 per cent. between absolute zero and their melting point.

That the great contraction occurring when, for example, 45 cubic centimeters of potassium united with 18 cubic centimeters of chlorine, giving as a result only 37 cubic centimeters of chloride of potassium, did not, as had been supposed by Ostwald and others, show that the atoms were far apart

from each other, or that the same atom might have different volumes in different combinations, but in fact proved the contrary. For, since annealed metals are isotropic, their atoms must be arranged as in Fig. 1. That if by pressure or otherwise they were forced over as in Fig. 2, there would then be more atoms per sq. cm. in one direction than in another, therefore the metal would be stronger in that direction than in the other, i. e., it would be laminated.

If other atoms, smaller, were introduced in the gaps, they would pull the larger atoms over, as in Fig. 3, where potassium and chlorine atoms are shown in their relative sizes.

The result, therefore, of rolling is to make a metal extra weak in one plane i. e., to laminate it. The effect of adding other atoms to it is to make it weak in three planes, i. e., crystalline (see Figs. 2 and 3).



Chemical affinity and cohesion being thus manifestations of the same force, the only difference being that cohesion gives results symmetrical in all directions, but chemical affinity results which are only symmetrical about certain lines or planes.

It was then pointed out that the contraction of any salts could be predicted by measuring the volume occupied by paraffine balls, made on a scale proportional to the size of the atoms. By taking, for instance, enough paraffine balls, each one centimeter in diameter, to occupy 45 cubic centimeters, representing potassium atoms, then taking an equal number of

balls occupying only 18 cubic centimeters, representing chlorine atoms, on mixing the two they would be found to occupy only 35 cubic centimeters, very close to that found in practice for chloride of potassium, and on the right side. We are also thus enabled to predict the shape of crystals.

It was then pointed out that all atoms had the same quantity of electricity on them, and hence the following law :

Every atom attracts every other atom with the same force when there is the same distance between their centers.

Consequently the strength and rigidity of metals depend upon the number of atoms per sq. cen. cross section and inversely as the square of the distance any two layers are apart. This is, since the atoms are nearly touching each other in the solid state, approximately inversely proportional to the fourth power of the radius of the atoms, or, to the $\frac{4}{3}$ power of the atomic volume.

Calculating by the electrical formula, force = $\frac{Q^2}{L^2}$, the force between the atoms of silver, we get. for a wire 1 mm. diameter.

Calculated tensile strength,	Observed, Wertheim,
45 kilos.	38 kilos.

The following tables show the agreement between theory and observation. It may be said that the mean of the observations agrees better with the theory than the separate observations do with each other.

FORMULÆ.

Tensile strength = (constant \times absolute temperature of melting point) \div (atomic vol.) $\frac{4}{3}$.

Rigidity = constant \div (atom vol.) $\frac{4}{3}$.

Electric Resistivity = $C \times V \frac{\text{atom weight}}{\text{atom vol.}} \times \text{valency.}$

	Rigidity.		Tensile Strength.	
	Calc.	Observed.	Calc.	Observed.
Iron.....	483	750	74	65
Copper	483	430	48	41
Zinc.....	314	350	18	15.7
Silver.....	270	280	29	29.6
Gold.....	270	270	29	28.5
Aluminum.....	250	250	18	18
Magnesium.....	154	150	9	9
Tin.....	122	136	5	3.4
Lead.....	100	84	4	2.36
Cadmium.....	180	not known.	10	not known.

The following table of the relative sizes of atoms (got) by dividing the atomic weight by the density) may be of use :

Carbon.....	3.4	Manganese	7	Cadmium	13
Boron.....	4.1	Zinc.....	9.2	Magnes..	14
Chromium.	7	Silver.....	10.2	Tin.....	16
Iron.....	7.1	Gold.....	10.2	Lead.....	18
Copper.....	7.1	Aluminum.	10.3		

From it we see why diamond is the hardest substance known; why iron and copper are the strongest metals (with the exception of another metal whose properties, the author discovered some years ago, i.e., glucinum, which is lighter than aluminium, stronger than iron, less tarnishable than silver or aluminium, and a better electrical conductor than copper); also why adding carbon or chromium to iron hardens it; we can predict that by adding boron to iron or copper we can harden them; why lead is so soft, etc.

Some hard things may appear soft on account of their being laminated or crystalline. For instance, a pile of slates might, on being pushed by a child, be disrupted, while the same child could not affect an equally sized mass of chalk. So graphite appears soft, as on pressing it the scales slide over one another, but in reality it is probably equally or slightly harder than diamond. It should be remembered that *pure* iron is quite soft.

It was then pointed out that, when a hard and rigid alloy is wanted, one should add little atoms, like filling in gravel

between larger stones for cement work, as was found experimentally years ago by Sir Roberts-Austen. If one wants the opposite, use big atoms. Similarly for great or little magnetic hysteresis.

So by taking that metal which has the smallest atoms of all metals, i. e., iron, and adding to it that metalloid which has the smallest atoms of all metalloids, i. e., carbon, we get that material upon which the city of Pittsburg bases its prosperity—evidently, as theory predicts, the strongest material which can be made in this world.

NOTE.—The tensile strength of magnesium was predicted by the author in *Science*, July 22, 1892, and the prediction was verified by Thurston in 1896. The formula for Young's Modulus is the same as that for rigidity, but with a different constant, the agreement with observed results being equally close.

MEETING OF THE CHEMICAL SECTION.

PITTSBURG, Sept. 22d, 1898.

The regular monthly meeting of the Chemical Section was held September 22d, 1898.

Chairman, J. O. Handy.

Attendance, 11.

The minutes of the last meeting were read and approved.

Dr. E. S. Johnson read a paper on the manufacture of Fuchsine, Alizerine and the Azo-Colors.

A BRIEF REVIEW OF THE MORE IMPORTANT
SERIES OF ARTIFICIAL ORGANIC
DYE-STUFFS.

BY EDWARD S. JOHNSON.

II. COLORING MATTERS OF THE TRIPHENYLMETHANE,
ANTHRAQUINONE AND AZO- SERIES.

B. *MANUFACTURE OF FUCHSINE, ALIZERINE
AND THE AZO-COLORS.*¹

APPARATUS.

Originating in the scientific chemical laboratory, the processes of the manufacture of the artificial coloring matters are, in their execution, obviously but adaptations of laboratory methods and appliances to a magnified application. Where the product of the laboratory is but a few grams, or at most a few hundred grams, that of the industry is represented by hundreds and thousands of pounds.

¹ In a more comprehensive study of the subject reference may be made, among others, to the works of Schultz, Friedländer and Harmsen already mentioned, and to literary sources there quoted.

A first necessity in respect to a laboratory process destined to technical application is therefore a corresponding increase in the capacity of the apparatus in which the process is to be realized; this involves resort to other constructive materials. Beakers, flasks, and evaporating dishes of glass and porcelain are replaced by great *vats, tanks* and *cisterns* of wood and iron, and the *open pan-* and *vacuum-evaporators*, usually of iron. The attack upon these materials of corrosive reagents becomes a question of moment; it is prevented by the use of various linings among which lead and enamels, as well-known, are most frequently adopted. The introduction of vessels 'of *cast-iron*,' by Nicholson, was a valuable addition to the then available structural materials for use in connection with acid operations.

Heat for solution, supporting reactions, evaporation, distillation, etc., is applied in the fewest cases by direct firing as by the gas-burners of the laboratory; *live-steam*, and high pressure and superheated *steam in coils*, a familiar fact, are the general sources of heat.

The manipulation of stirring, as a rule essential to expeditious and perfect reaction, and emphatically so in the processes of the dye-stuff manufacture, is, as need scarcely be mentioned, executed by *mechanical stirrers* of which the laboratory prototype is the glass rod driven by muscular energy.

Devices for the *separation of solids from liquids*, filter-presses, centrifugal machines, hydraulic presses, perform the work of the filter-pumps, filter-paper and hand-pressure, the porous plates, etc.

1 Caro: *Entw. d. Theerfarben-Industrie*, Ber. d. deutsch. chem. Ges. 25c, 988.

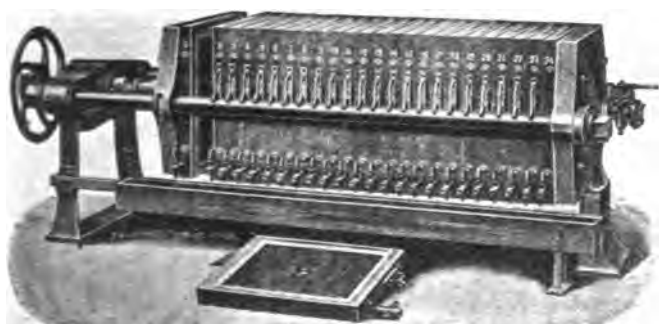


Fig. 10. FILTER-PRESS, (Recessed-Plate Machine).

The *edge-mills*, *ball-mills* and *disintegrators* in numerous modifications, in constant use for the preparation of solids for the transformations of the manufacture, or of the finished product for consumption, are the industrial representatives of the laboratory mortar.

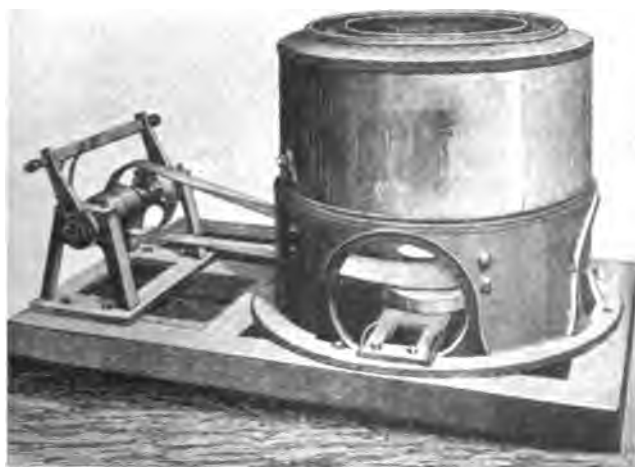


Fig. 11. CENTRIFUGAL MACHINE, (Under-Driven).

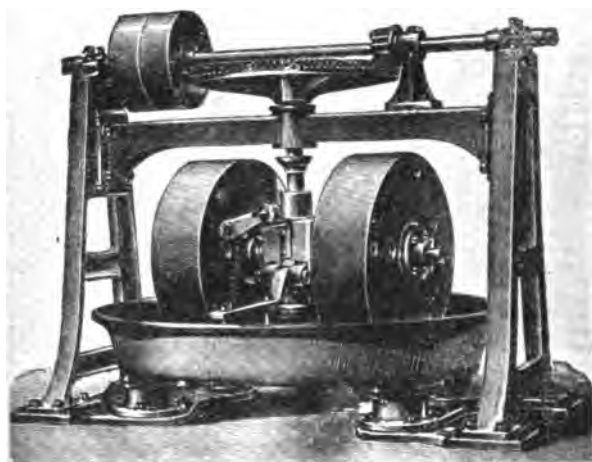


Fig. 12. EDGE-MILL.



Fig. 13. BALL-MILL.

Fig. 1. Schematic diagram of the apparatus.



Fig. 2. Schematic diagram of the apparatus.



Fig. 3. Schematic diagram of the apparatus.

These and similar instances have doubtless already suggested themselves, and will not be multiplied; it is interesting to note in passing, however, that numerous forms of the technical appliances that have been named have found their way in miniature to the laboratory where they greatly facilitate its work. The mechanical stirrers, agitators, grinders, and the autoclave are abundantly in evidence in the modern laboratory.

FUCHSINE.

A SYNTHETIC METHOD.

It will be recalled that paraamidobenzaldehyde reacts with aniline, forming triamidotriphenylmethane or paraleucaniline. The yield is nearly theoretical from cheap materials, and the utilization of the reaction in the manufacture of fuchsine has accordingly been the object of repeated efforts since its discovery by Fischer twenty years ago. The methods attempted for the oxidation of the leuco-base to the coloring matter, until recently, have been wholly unsuccessful from an economic stand-point; the output has been so sparing that the fuchsine formation was but a secondary feature of the oxidation.

In 1892 it was observed, in the laboratory of the Farbwerke vormals Meister, Lucius and Brüning, that the chief difficulty of the oxidation, the transmission of the process to the coloring matter itself, is obviated by the use of a solvent during the oxidation, in which the leuco-base is readily, and the dye-stuff difficultly, soluble; the latter is therefore separated as formed and removed from the destructive action of the oxidizer. Acetone and methyl or ethyl alcohol, to which common salt solution has been added, perfectly serve the purpose. The method in detail is given essentially as originally communicated¹:

The iron vessel in which the reaction is effected has a capacity of about 25 gallons, is provided with stirrer, and in the cover with attachments for distillation and an opening to

admit the charge. It further stands in a water-bath filled at the beginning of the oxidation with cold water.

The charge, consisting of 25 pounds of parateucaniline, is introduced with 4 pounds of acetone; by a few revolutions of the stirrer the mass is completely dissolved.

With constant stirring 25 to 30 pounds of dilute acetic acid, two and one-half gallons of salt solution, five pounds of salt, and the calculated quantity of manganese peroxide in the form of finely ground pyrolusite or "manganese mud" are added. The oxidizer is filled in slowly, the whole quantity in the course of half an hour. The stirring is continued for one hour in the cold, when the water-bath is heated to 60-70°C. Acetone distills over, and parafuchsine together with basic manganese salts, acetic acid and salt solution remains in the still. Extraction of the residue with water and precipitation of the filtered solution with salt separate the dye in pure form. The output by a carefully conducted operation is almost theoretical.

THE EMPIRICAL PROCESSES.

The manufacture of fuchsine by the oxidation of "aniline oil for red" has been since its first successful application at all times a most important branch of the artificial color industry from every point of view. For nearly forty years it has been operated by the arsenic process, and during twenty-five years or thereabouts the nitrobenzene method, with its several advantages over the older process, has attained to even more extended, although not an exclusive, application. The history of the industry and its present technical standing command attention for it. The interest elicited is perhaps augmented, aside from through the disadvantageous contrast afforded with the synthetic method in simplicity and expedition of execution, and perfect reaction, by the prospect of its being generally sup-

¹ Friedländer: *Fortschritte d. Theerfarbenfabrikation*, III., 110; German Patents 70,000 and 72,032.

planted in the not distant future by the new manufacture operating according to the synthesis just described or other similar rational procedures.

Attention to both the older methods will be requested, and in the first instance to the

1. ARSENIC ACID PROCESS.

The manufacture in this form is based upon the oxidizing action of a strong arsenic acid solution upon a mixture of aniline, ortho- and paratoluidine at a temperature of about 180°C .

The mixture of bases as actually used in the *charge* is never the theoretical, one molecule of each, nor even approximately so. As a rule one part of aniline and two parts of technical toluidine are applied. As the latter contains both the ortho- and para-isomers, and the para-compound to the amount of about 36 per cent., the mixture for oxidation is composed of 33.3 per cent. aniline, 24 per cent. paratoluidine, and 42.7 per cent. orthotoluidine. The calculated ratio of aniline to each of the toluidines would be 30 to 35; aniline and orthotoluidine are therefore in excess. This preponderance is necessary to the best results; the fusion is thereby diluted and kept open to the action of the oxidizer.

The *arsenic acid solution* for the oxidation contains 60—75 per cent. orthoarsenic acid, H_3AsO_4 .

The *apparatus* in which the reaction, technically known as the fusion or melt, is carried out is reproduced by Figs.¹ 16 and 17, the first being, as is plain without comment, an exterior, and the second, a schematic section of a similar vessel mounted. The whole is simply a cast-iron, cylindrical retort set in masonry. It is equipped with mechanical stirrer and

¹ Figs. 10, 11, 12, 13, 14, 15, 17, and 19, are from Harmsen; *Die Fabrikation d Theerfarbstoffe u. ihrer Rohmaterialien*; 16 and 14, from Schuitz; *Chemie d. Steinkohlentheers*.

charging and below the discharge-opening. Through a hole in the top of the retort, samples of the fusion may be withdrawn as the reaction proceeds. The goose-neck connects with a condenser not shown in the sketch. In the capacity of tube for thermometer; above will be noticed the man-hole for melting-pots there is naturally much variation; they are constructed for charges of a few hundred pounds only, and again, in the larger works, for as much as a ton or more of red oil.



Fig. 16.

The *melt* is conducted by heating a mixture of the oil and arsenic acid solution in the ratio of 1 to 1.5–1.7 from eight to ten hours with constant stirring. During this time the temperature is slowly increased to 180°. At 100° the distillation of

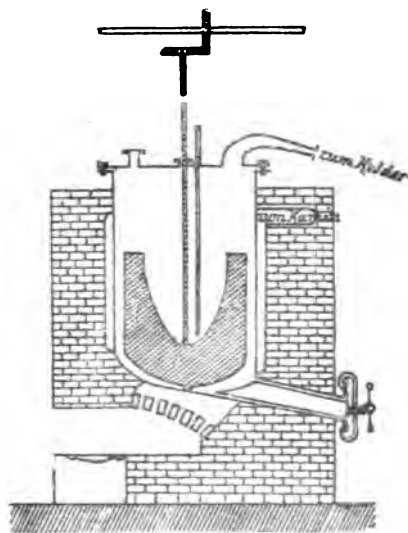
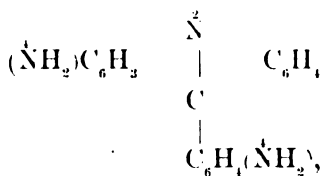


Fig. 17.

water begins and is followed throughout, as the temperature rises, by vapors of water (now from the reaction), aniline and orthotoluidine; the volume of the distillate affords a means of noting the stage of the melt. Direct tests of its condition are begun at the end of seven hours when the thermometer should indicate about 180° , a temperature to be carefully held but not exceeded; above 190° decomposition of the coloring matter already formed begins. The testing is continued until a sample upon cooling solidifies to a brittle, bronze-colored mass. At this stage nearly or quite one-half the oil of the charge will have passed into the receiver serving the condenser. It is known by its original name as the *schlappes* and utilized, after a second fusion with fresh portions of red oil, in the azo-department of the works, and in the preparation of saffranine. The fusion is then tapped out and received in sheet-iron pans where it soon sets. The cakes formed are reduced to coarse fragments preparatory to the *extraction*.

The mass is a mixture of pararosaniline and rosaniline arsenite and arsenate together with the same salts in small quantities of chrysaniline or phosphine, an asymmetric diamidophenylacridine,



of mauvaniline and violaniline, bases of uncertain constitution, but is largely composed of nondescript tarry materials; with these are inevitably associated residues of arsenious and arsenic acid.

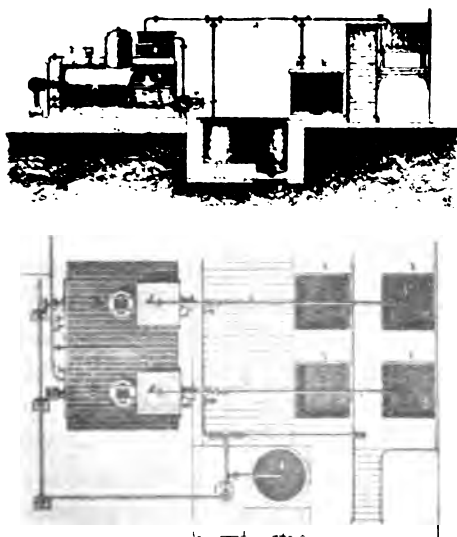


Fig. 18.

Apparatus for the Extraction of the Fuchsine Fusion
and the Preparation of Crystal Fuchsine.

The construction of the extractor or "boiler" whose function is the disintegration of the fusion and its separation into fractions soluble and insoluble in water, may be seen in the illustration, Fig. 18. It is a horizontal cylindrical vessel strongly constructed of boiler-plate, and mounted in a furnace or surrounded by a steam-jacket. The usual provisions for filling and stirring are made; at *c* a box enclosing a felt-filter is attached. The boiler connects by a system of pipes with vats for retaining the extraction, separation of the crude coloring matter, and handling the mother-liquor from the latter. The capacity of the boiler for a charge of 1000 pounds of red oil is about 1200 gallons. Before charging a melt of this quantity, 710 gallons of water, 'residue extract' or the mother-liquors of a former operation are heated in the extractor to boiling. The melt is then added and digested at a pressure of one and a half atmosphere for one hour. During this interval the stirrer is constantly in motion.

The residue is allowed to subside, and the partially cleared fluid forced by steam pressure through the filter and thence into the upper vat in which it is treated with hydrochloric acid, and then with common salt, in weight equal to that of the fusion. A double decomposition takes place between the arsenites and arsenates of the color-bases, and the salt; *crude fuchsine* separates in the course of about two days. This, together with small portions, regained subsequently from the mother-liquors, is placed in an extractor and redissolved in the same volume of water used on the melt. Soda to the amount of 30 pounds is added gradually to the solution, and the precipitate formed, which contains valuable by-products, is set aside for special treatment. The clear solution is forced into wooden vats and there mixed with empirical quantities of hydrochloric acid and salt. The surface of the hot fluid is closely covered with boards, obviously to prevent too rapid cooling and to increase the surface exposed for the deposit of crystals. Pieces of wood and boards weighted with lead are also submerged in the vats.

The crystallization is allowed to continue for about three days. The mother-liquor is drawn off, and the crystals, after thoroughly draining, are scraped from the vat and planks, dried, and separated by passage through sieves into the several brands of *crystal fuchsine*.

The mother-liquor from the crude product and that from the crystals are united and precipitated warm with soda in the lower tanks in which, in the meantime, they have been collected. The precipitate is composed mainly of fuchsine bases and phosphine, and is one of the manufacturer's important *by-products*. It is designated *crude cerise*; from it various brands of *cerise*, differing in the ratio of fuchsine to phosphine, are prepared. The crude material, when sufficient has accumulated, to this end is dissolved in water and hydrochloric acid in the extractor, and the solution filtered; precipitation with acid and salt follows. Crude fuchsine, which is united with the main product, separates in small quantity. By precipitation with soda, *cerise* is obtained from the mother-liquor and converted into chloride, its applicable form. The filtrate from crude *cerise* is made alkaline with lime and distilled with steam. The bases obtained are added to the *échappés*.

The *crystal residue*, from the partial precipitation of the re-solution of the crude fuchsine, contains, besides fuchsine bases and phosphine, violaniline and mauvaniline, basic oxidation-products of aniline; small portions of crude fuchsine and *cerise*, together with maroon, are recovered from it. By digestion with dilute arsenic acid, the former are removed; crude fuchsine is precipitated as before, and in the filtrate crude *cerise* is separated by soda. The residue from the arsenic acid extraction is boiled with dilute hydrochloric acid; from the solution a brown coloring matter, *maroon* above mentioned, is obtained by precipitation with soda and redissolving the collected precipitate in hydrochloric acid, the main solution having first been freed by soda from small quantities of fuchsine bases and phosphine.

Phosphine, a valuable fast dye of yellow shade, much used in leather dyeing, is prepared from cerise. The hydrochloric solution is first reduced with zinc dust; the fuchsine present is thereby decolorized. The separation of the phosphine is then accomplished by precipitation with sodium nitrate, sparingly soluble phosphine nitrate and sodium chloride being formed.

The disposal of the *arsenic residues* of the manufacture was long a vexed problem finally successfully solved by Leonhardt. The arsenic liquors are evaporated to dryness leaving essentially sodium chloride, arsenite and arsenate. These salts are mixed with the organic residues of the industry, and heated with admission of sufficient air to but partially burn the whole. The heat of the combustion is utilized in the evaporation of the arsenical liquors contained in iron pans upon the furnace. The volatile products of the partial combustion, during which arsenic is present mainly uncombined, are conducted into condensation-chambers where air is admitted and oxidizes the arsenic to trioxide. The latter is further completely condensed and removed. Treatment with nitric acid converts it into arsenic acid which is then returned to the manufacture.

The best yield of crystallized fuchsine from the arsenic process is 35 per cent. of the red oil used.

2. NITROBENZENE PROCESS.

In the fuchsine formation by the action of nitrobenzene (-toluene) together with ferrous chloride upon red oil, the chemical process is one of oxidation by transmission. Ferrous chloride is converted by oxygen of the nitro-compound and the added hydrochloric acid into ferric chloride; this, in the presence of the water formed, is directly the oxidizing agent. The oxidation produces fuchsine and regenerates ferrous chloride which continues the mediation.

With nitrobenzene alone there is no reaction.

Although not without contention of the contrary on the part of certain investigators, it seems now to be generally

admitted that the nitrobenzene itself acts purely as a source of oxygen, does not enter into the fuchsine molecule, and is transformed into tarry substances which perhaps contain compounds of the induline series.

The *aniline oil* of the *charge* for the nitrobenzene process is of different composition from that of the arsenic process. It contains, with the use of nitrobenzene, as much as 80 per cent. toluidine, the amount varying in the practice of different manufacturers; when nitrotoluene is the oxidizer, the quantity is reduced to about 55 per cent. Still other ratios of aniline to toluidine deviating considerably from these might be quoted as representing in general the conditions concerned. The variations are to be ascribed to the empiricism of the method, and partly to the difficulty of estimating the ingredients with accuracy. In practice new raw materials are selected mainly by a comparison of their physical constants with those of products which have stood the test of long experience. Where the yield is far from quantitative, it is evident that mixtures of the same constituents, relatively differing much in composition, may be made to produce the same results.

Nitrobenzene is added to the amount of about 50 per cent. of the oil; nitrotoluene is required in larger quantities, 60-65 per cent.

As regards the quantity of *ferrous chloride* applied, a general usage seems to be that formed from two to three per cent. iron borings, the oil as before being the basis; in this respect also much variation may be observed.

The *melting-pot* is of similar construction to that already described and illustrated for the oxidation by arsenic acid. It is shown in section in Fig. 19. Mounted for heating as in the instance mentioned, it, however, has special attachments for cold water and steam by which the temperature may be closely regulated. The goose-neck is higher for the retention of the aniline which boils at about the temperature of the reaction. It is the custom to use larger charges than in the

arsenic process; pots for quantities of more than two tons of oil have been used.

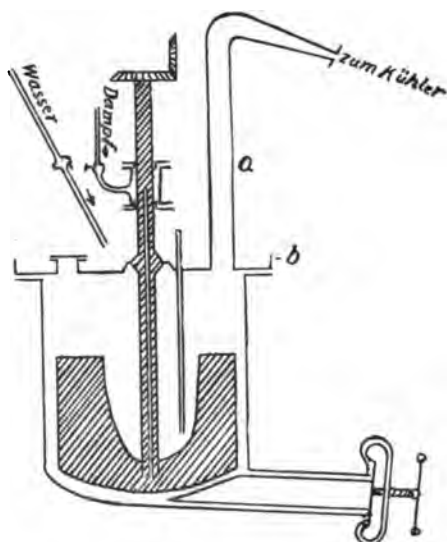


Fig. 19.

To prepare *the melt* part (one-half to two-thirds) of the aniline oil is dissolved in the calculated quantity of hydrochloric acid, the solution mixed with the ferrous chloride, and the whole evaporated in an enameled vessel or similar apparatus to thorough dryness, finally being heated to 130-140°C. The exclusion of water from the reaction is important, nitrobenzene in its presence being reduced by ferrous chloride to aniline.

The rest of the aniline, the mixture of the salts of aniline and iron, and the oxidizer are charged into the retort and heated. The heating requires special precaution; a rise of the temperature above 180° being carefully guarded against. The formation of fuchsine begins at 160°. The fusion requires eight to ten hours; its progress is observed by sampling, as before. The heating is continued until a sample solidifies

upon cooling without becoming brittle. At this point steam is conducted into the retort through the hollow axle of the stirrer, and the passage continued until the excess of "nitro" and oil is removed. The fusion is then withdrawn. When cold it should be brittle, an evidence of sufficient separation of the oils. These, collected from the receiver for the condenser, are put through the aniline-stills.

The melt before *extraction* must be freed from chlorides of iron, aniline, etc. It is therefore boiled with hydrochloric acid and salt solution. The aniline is recovered from the washings. The extraction which follows and further manipulations for the separation of the color are such as already described for the arsenic process.

The output of crystallized dye-stuff, under most favorable conditions, is 42 per cent. of the aniline applied. Although a somewhat less handsome preparation, it has the advantage over that from the older process of being free from poisonous contamination. Better yield, equally economic manufacture, and a product of satisfactory quality, have given the nitrobenzene process the upper hand in competition with its rival.

ALIZERINE.

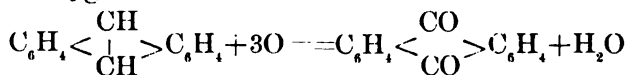
The manufacture of alizerine has been ruled from its inception by rational methods. Its very beginning resulted from a purposed effort to confirm a theoretical deduction by experiment.

The operations to be considered are, in the order named, the *oxidation* of anthracene to anthraquinone, the *sulphonation* of the latter, and the *alkaline fusion* of the anthraquinonesulphonic acids obtained.

PREPARATION OF ANTHRAQUINONE.

Under the influence of certain oxidants (nitric acid, chromic acid) anthracene, as already discussed, is converted

into anthraquinone. One molecule of anthracene and three atoms of oxygen are the elements of the reaction:



Anthracene.

Anthraquinone.

The crude anthracene used is first assayed by the method of Luck¹, which admits of exact determinations. The results serve to guide the oxidation.

The necessary nascent oxygen is derived from sodium chromate and sulphuric acid. The former, in calculated quantity, is dissolved in about fifteen parts of water in a lead-lined vat of about 750 gallons capacity for 250 pounds of crude anthracene, and the solution heated to boiling by direct steam. The finely ground anthracene is next added, the stirrer with which the vat is fitted being in constant action. After cutting off the current of steam, the required amount of 33 per cent. sulphuric acid is syphoned into the vat in the course of nine to ten hours; its contents are uninterruptedly agitated. Steam is again turned on, and the heating at a boiling temperature continued for a short time.

By filter-presses the resulting impure anthraquinone is separated from the chromium solution, and, after drying and grinding, is heated and stirred with two to three parts of concentrated sulphuric acid. These conditions are maintained until the anthraquinone has dissolved, and, upon pouring a portion of the solution into water, separates as a nearly pure white precipitate. The temperature is increased finally to 110°C. Anthraquinone dissolves without being attacked. Its main impurities, on the other hand, phenanthrene, acridine, carbazol, and their oxidation products, such as phenanthrene-quinone and the quinones from carbazol, together with acridine chromate, are rendered soluble by sulphonation or decomposition; upon dilution with water they remain dissolved, and may be separated from the precipitated anthraquinone by fil-

¹ *Zeitschr. f. Analyt. Chemie.* 16, 61.

tration. The solution is transferred to a leaden pan and allowed to cool in a moist atmosphere. Anthraquinone crystallizes in small quantity; the whole of it is precipitated by the addition of 20 volumes of water. This mode of separation yields a crystalline product which is easily filtered. Washing with water and dilute soda solution completes the purification for ordinary applications. It is a light yellow crystalline powder containing 92 to 95 per cent. pure anthraquinone.

A prominent feature in the economy of the process is the recovery of the chromium in the filtrate from the crude preparation; it is regenerated to chromate for re-application. Precipitation with magnesia or lime, and oxidation by heating with excess of the latter in the air accomplish the transformation in accordance with familiar reactions.

SULPHONATION OF ANTHRAQUINONE.

The technical sulphonation of anthraquinone may have for its object the preparation of a pure monosulphonic acid for pure alizerine of "bluish shade," or of alpha- and betadisulphonic acids used in the manufacture respectively of flavo- and isopurpurine.

Anthraquinonemonosulphonic acid is obtained by the action of fuming sulphuric acid, containing 40 to 45 per cent. sulphuric anhydride, upon an equal weight of 95 per cent. anthraquinone at a temperature of 160°. The materials are placed in an enameled cast-iron pot. During the several hours in which the heating of the mixture is continued thorough stirring is indispensable. Under these circumstances 20 to 25 per cent. of the anthraquinone remain unattacked. The contents of the sulphonation-pot are poured slowly into boiling water, the boiling being maintained for some time. The residual anthraquinone, which precipitates, is removed by filtration, washed, and worked over in following operations. The filtrate, after neutralization of free acid by caustic soda, deposits (if necessary, after some concentration) the difficultly soluble

sodium monosulphonate as crystalline scales. Its brilliant, pearly lustre causes the salt to be known among the German manufacturers as "silver salt;" in England it is also familiarly known as "soda salt." More of the compound is separated by concentration of the mother-liquor. Recrystallization effects a thorough purification.

The liquors from the second crop of crystals contain 20 to 30 per cent. of the anthraquinone as two *isomeric disulphonates*. These are further directly prepared in mixture by heating the quinone with two to three parts of fuming sulphuric acid until dilution no longer causes precipitation. An hour's additional heating finishes the conversion from the mixture of mono- and disulphonic acid first formed to the derivatives. After dilution and neutralization as before, the solution is concentrated and the sulphonates obtained separated by crystallization. The salt of the alpha-acid, as much less soluble than its isomer, crystallizes first. The relative amount of the acids in the mixture may be varied by adjustment of the temperature. At higher temperatures, the alpha-compound is mainly produced; a decrease favors the formation of the beta-acid.

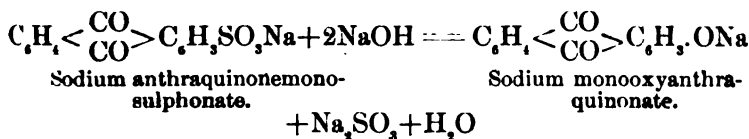
THE FUSION.

The general reaction illustrating the formation of the oxyanthraquinones from anthraquinonesulphonic acids by fusion with caustic alkali was considered when treating of the chemistry of the alizerine colors. After the nature of the reaction had been fully determined, the manufacturer, in the early history of the industry, sought to introduce the oxygen found necessary by exposing the fusion to the air. This was practically carried out with increased, but still meagre, yields by stirring the melt in open pots. An improvement is to be noted in a manipulation consisting in removing the fusion from the melting pots, after it had thickened to a stiff, pasty consistence, and spreading it out in pans heated on the shelves of a capacious oil-bath.

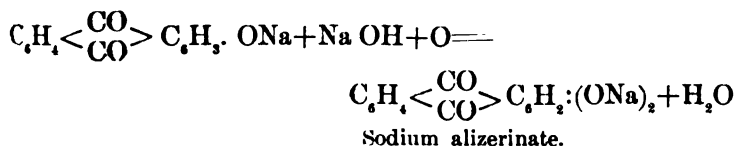
The present procedure, first proposed by J. J. Koch, is to melt in closed vessels with the addition of potassium chlorate to supply the required oxygen. It thereby became possible to completely control the concentration, the amount of oxygen, and the temperature, details upon which the success of the reaction vitally depends, and produce almost theoretical yields. For twenty-five years the process in this form has been in use, and its adoption marks the last advance toward the state of perfection in which the industry of to-day operates.

The equations below will exhibit in detail the process in its theoretical phases:

I.

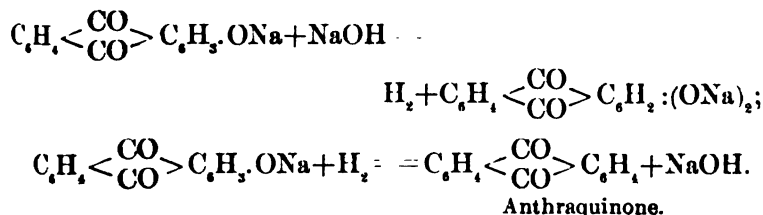


II.



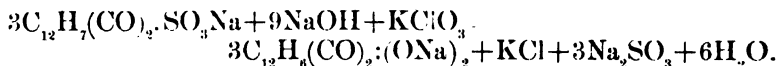
In the absence of oxygen from external sources during fusion, hydrogen is generated; this in nascent state, acting upon oxyanthraquinone already formed, regenerates anthraquinone, rendering thus a portion of the sulphonate ineffective:

III.



Combining phases I. and II. into one equation, an expression of the technical reaction, in the presence of added oxygen, is as follows :

IV.



The appliances for its execution are a horizontal (under certain conditions, upright) soft steel cylinder, the digester, capable of resisting a pressure of at least twenty atmospheres, and the vats for the solution of the fusion, precipitation of the dye-stuff and the mixing of the latter to a standard percentage with water. The digester varies in capacity from 500 to 2000 gallons, fusions for pure alizerine being made preferably in the smaller cylinders, the admixtures with purpurines in the more capacious vessels. Each is provided with a stirrer so fitted that its paddles move close to the walls of the cylinder, and prevent by this arrangement the caking and burning of the fusion on the hottest parts. The remaining features and attachments, openings for charging, discharging and sampling, safety-valve, manometer, and thermometer need scarcely be mentioned. The digester is heated directly in a furnace, or by air- or oil-bath.

For *pure alizerine*, the fusion is begun by charging 600-700 pounds of soda or silver salt, 2.5 parts of caustic soda, 0.13 parts of potassium chlorate (as required by equation IV), and sufficient water to nearly or barely liquify the mixture. The openings of the digester are securely fastened, and its contents heated at a temperature of 180° for about two days. After the reaction is well advanced to completion, samples of the melt are examined in the laboratory ; the time for discontinuing the heating is thereby definitely determined. The disappearance, as shown by the tests, of the oxyanthraquinone first formed (equation I.) indicates the end of the reaction. To test for the monooxy-derivative, the sample is dissolved in water and the solution treated with excess of lime. To the

filtrate from the precipitate which separates, hydrochloric acid is added; a yellow precipitation occurs if the fusion still contain monooxyanthraquinone.

The time required for a melt as described may be materially shortened by modification of the relative amount of the ingredients; the use of about 18 instead of 13 per cent. potassium chlorate, and a concentration by reduction of the amount of water to somewhat less than four parts, decrease the time for the complete transformation of the sulphonate to 20 to 24 hours. The temperature of fusion is 160°.

Fusions under the conditions first enumerated are fluid when done, and may be forced by the high pressure within the digester directly into the precipitating-vat which already contains a large portion of the total amount of water to be added. The more rapid melts are of such consistency that they must undergo dilution before removal. The purple solution of the melt in either case is diluted in the vat to a gravity of about 1.10, and acidified hot with hydrochloric or sulphuric acid. The dye-stuff separates as a brownish yellow, amorphous precipitate, and, after subsiding and the decantation of the supernatant fluid, is collected and washed in the filter-presses. Still moist it is transferred to the mixer, a wooden tank, in which it is agitated to uniformity of composition with water. The percentage of alizerine in the resulting paste is determined, and the content adjusted, by addition of water, to the commercial standard of 20 per cent.

In the preparation of *mixtures of alizerin and purpurines* (flavo- and iso-) the process is throughout similar to that just described, monosulphonate being replaced by the mixture of sulphonates (mono- and di-) obtained from anthraquinone by neutralization and evaporation in the process of sulphonation already reviewed.

Flavopurpurine and *isopurpurine* are also objects of direct individual manufacture from the corresponding pure disulphonates.

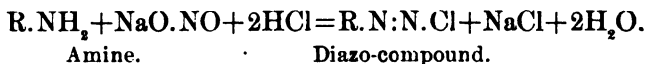
AZO- DYE-STUFFS.

In contrast with the branches of the color-manufacture thus far discussed, the preparation of the azo- coloring matters is of pronounced simplicity.

The chemical processes involved have already been generally treated; it remains to refer to them here more concretely, and to the means of technically conducting them. The appliances of the manufacture are vats for the diazotation and combination, filtering-apparatus, drying-ovens, and grinding-machines.

DIAZOTATION.

An amine, it is well-known, is converted by sodium nitrite and hydrochloric acid, each in proportions exactly corresponding to those of the equation following, into a diazo-compound:



Amine.

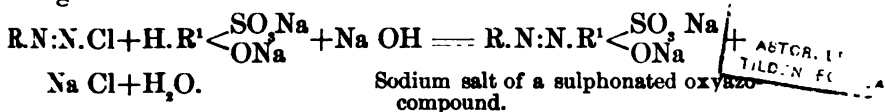
Diazo-compound.

The amido-compound is dissolved or suspended in hydrochloric acid and water in a wooden vat. The relative amount of water is dependent upon the solubility of the chloride of the compound, the readiness with which the components unite, and the solubility of the azo-compound to be produced. The actual quantities of the bases applied vary in different instances from comparatively a few to several hundred pounds. To the hydrochloric solution, that of the sodium nitrite is slowly added. Owing to the instability of the diazo-compounds, the temperature of both solutions is reduced to 4° to 5°C. before mixing, and afterwards cautiously kept, with few exceptions, below 8° by addition of ice. The addition of the nitrite is accompanied by vigorous stirring.

COMBINATION.

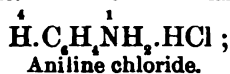
In the more usual case of a phenol or its sulphonic acid, in the manufacture of the *oxyazo-dye-stuffs*, the diazo-solution thus prepared is then gradually run into the solution

of the phenol dissolved in a quantity of alkali calculated to be in slight excess at the end of the combination :

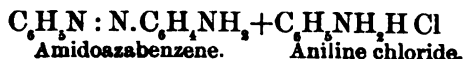


The alkaline solvent chosen depends upon the nature of the compound and the attendant practical advantages ; for the free naphthols caustic soda, for certain of the sulphonic acids ammonia, and for still others sodium carbonate are variously used. The solution is contained in a vat placed conveniently below the diazo-vat ; the transfer is, therefore, by simple gravitation. Precautions are taken to thoroughly mix, and hold the temperature to the low limits required in diazotation. At longest in the course of a few hours, the combination has taken place. The separation of the dye-stuff most frequently is simultaneous with its formation ; where the solubility is greater precipitation with saturated salt solution is resorted to ; others again are separated by acidification. The color is collected in the usual way, by the filter-press, washed slightly with salt-water, dried, ground, and standardized.

A description of the combination with amines, producing the *amidoazo-coloring matters*, would be a repetition in its main features of the foregoing. As a peculiarity should be mentioned the intermediate formation of diazoamido-compounds when primary monamines are combined. The equations showing the reaction of aniline and diazobenzene chloride will illustrate the subject :

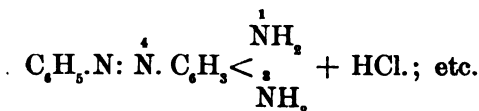
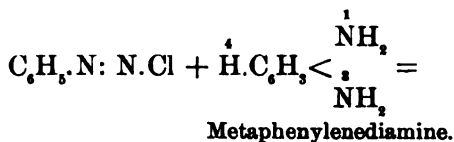
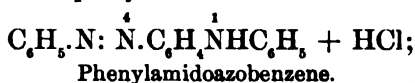
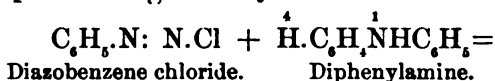


the mixture represented by the right-hand member of the equation, when heated to 30°—40° becomes, with excess of aniline,



The formation of each molecule of amidoazo-compound is attended by a regeneration of amine chloride, which again exerts its isomerizing influence upon a further portion of the diazoamido-compound. The excess of amine serves doubly to neutralize the acid formed, and thus facilitate the combination, and also to dissolve the diazoamido-compound, furnishing a medium for the intramolecular change.

In combining with secondary and tertiary amines, as diphenylamine and dimethylaniline, the primary diamines (metaphenylene diamine for example), and still others, the reaction takes the normal course described for phenols, the amidoazo-compound being directly formed:



The amine is prepared for combination by solution in water, hydrochloric acid or occasionally alcohol. It is usually an advantage or necessity to neutralize the mineral acid liberated in the reaction; sodium carbonate or acetate may be applied.

Whether a phenol or an amine be the component for combination to azo- dye-stuffs, its application and that of all principals to the reaction should be as a rule in quantities theoretically prescribed. Otherwise impure, impracticable colors will

result. The outputs in both groups of the series closely approximate the amounts calculated.

THE TECHNICAL CHARACTERIZATION OF THE COLORING MATTERS.

The colorations produced by dye-stuffs, natural or artificial, exhibit great variation in capacity to resist the attacks of physical and chemical agencies to which of necessity they are exposed in the course of their formation upon animal and vegetable fibre, etc., and the later application of the latter, whether considered from the stand-point of a given color or a given agency.

The degree of permanence of the colorings under the action of light, friction, milling, water, soap, alkali, acids, etc., or *fastness*, becomes a factor for most careful consideration by the manufacturer. The *newly invented dye-stuff*, therefore, upon emerging from the research laboratories of the color-works is passed first into the laboratory of their scientific colorists. There it undergoes a series of rigorous tests relative to the processes of the dye-house and its general serviceability. It is thereby characterized as to the possibilities of its application.

The fewest of the artificial colors are marketed even in a measure as pure substances. Particularly is this true of the azo-colors. As taken from the filter or hydraulic presses, the drying-ovens, and finally from the grinding-machines, they more usually appear as amorphous or at most fine, crystalline powders containing as impurities varying quantities of the salts of the imperfectly separated mother-liquor. Besides, for reasons of competition and practical advantage, color-preparations are purposely dilutions of the purer dye-stuff by substances which in no wise interfere with their use. A prime requisite of the consumer, however he may choose to purchase a dye in regard to the percentage of active principle, is evidently a product of known practical effect. When a new stock of a *coloring matter of established repute* is prepared, the obli-

gation to adjust it to the standard of commercial usage is evidently imposed. Preparatory to the standardizing, by mixing with salt, sodium sulphate, or other indifferent, soluble materials, a determination of the amount of dye-stuff in the preparation, as obtained in the manufacture, is required.

The method universally adopted by the color-manufacturer for the *quantitative estimation* of the worth of his commodities, where direct, absolute determinations are not practicable, assumes the form of a relative assay of the coloring matter under conditions which are carefully adjusted to imitate in all essential details those which will prevail in its application. As a variety of colorimetric determination, it requires as a basis, for each product, a standard coloring matter, an empirical preparation, quantitatively known in its effect as a dye-stuff. This factor given, the determination will appear as a simple problem.

A weighed quantity, 0.5-1.0 gram each, of the known substance and of the other of still unknown effect is dissolved in water and diluted to one liter. Suitable aliquot parts are withdrawn and diluted to several hundred cubic centimeters in a beaker or casserol of porcelain. Exactly 10 grams of cotton or woollen yarn in skein are then dyed, one in each of the solutions, to the exhaustion of the color, the experiment being so set that the fibre is in excess and the conditions under which the coloring matter is to be used in the practice of the dyer are throughout exactly adhered to. Further dyings follow under like conditions and in accordance with the observations of the first until a coloration identical with that of the standard or but slightly lighter or darker is obtained. In event of the latter a trained eye readily estimates the amount of the original solution necessary to match the standard color. The volumes of the standard and tested solutions yielding the same effects are inversely proportional to the quantities of coloring matter contained by the preparations from which they were derived. Results are accurate within two to five per cent.

Besides determining percentages or, without reference to percentage, merely establishing the relative efficiency of the preparation as compared with the standard whose actual percentage of pure dye-stuff may or may not be known, the test further shows the gravic ratio of dye to material for a given effect.

When from the nature of the color it is impossible to exhaust the dye-bath, accurate estimations of efficiency are difficult. Comparisons of the colorations made upon blotting paper, cotton goods, etc., by dipping into solutions of a standard and those from varying quantities of the substance under examination, draining, and drying the colored samples are sometimes used to furnish the desired data; the results can only be said to approximate in value those obtained under the circumstances first described.

Thus technically characterized, the dye-stuffs have passed the last stage of their manufacture, and are then ready for distribution to the centers of at once a varied and an extensive application.

After a brief discussion of the paper the meeting adjourned at 10 P. M.

A. G. McKENNA, *Sec. C. S.*

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

ASTOR, LENOX AND
TILDEN FOUNDATION

The regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the lecture room of the society's house, 410 Penn avenue, Pittsburg, Pa., Tuesday evening, October 18th. The meeting was called to order by the president, Mr. Geo. S. Davison, at 8:25, twenty-five members and visitors being present.

The minutes of the last meeting were read and approved.

For the Board of Direction, the president stated that the request of the Library Committee for fifty dollars had been granted at the last meeting of the board.

MR. RICHARD G. G. MOLDENKE, Metallurgical Engineer for McConway & Torley Co., and

MR. JOSEPH S. SEAMAN, Manufacturer of Rolls, of Seaman, Sleeth & Black, were elected to membership.

Mr. Bentner, for the Reception Committee, reported that a lunch had been prepared to be partaken of after the adjournment of the regular meeting.

A member reported that since the last meeting, Mr. Jas. R. Moore, of Moorehead Bros. & Co., had died.

The president announced that the board had suggested to the Reception Committee that the society hold a smoker between this and the next regular meeting.

The paper for the evening was read by Mr. E. B. Taylor on "The Transportation of Iron Ore."

R. A. FESSENDEN, *Secretary.*

THE TRANSPORTATION OF IRON ORE.

BY EDWARD B. TAYLOR,

(GENERAL SUPERINTENDENT OF TRANSPORTATION, PENNSYLVANIA LINES
WEST OF PITTSBURG.)

In discussing this subject, I shall confine myself to the movements of the ores mined in the Lake Superior region, for the reason, that not only is it producing over two-thirds of all the ore mined in the United States, but it has for many years supplied practically all the ores used in the furnaces of Western Pennsylvania and the Ohio Valleys, and without which Pittsburgh could not have maintained its supremacy as the great iron center of the world.

The ore fields of the Lake Superior region extend from the Meridian, passing through Chicago, westward, to the Meridian, passing through Pokegama Falls, of the Mississippi, a distance of 250 miles, and the ore-bearing rock traverses the western half of the upper peninsula of Michigan, the eastern half of Wisconsin, and extends about 80 miles into Minnesota. The ore ranges, in their order of discovery, are the Marquette, lying within the upper peninsula of Michigan; the Menominee and the Gogebic, partly in Michigan and partly in Wisconsin, and the Vermillion and the Mesaba, wholly in Minnesota.

There is no question but what the Indians knew of the presence of iron ore in the Lake Superior region, and that as far back as 1830 the men employed by the American Fur Company saw the outcrop; but, for the fur hunter as well as the Indian, it had no commercial value. Mr. Richard A. Parker, in his valuable and interesting article on the Iron Ore Region of Lake Superior, states that the first actual record of its presence is found among the papers of Wm. A. Burt, who, while surveying in 1844, "on the East line of Township 47 North, range 27 West, in Michigan, observed, by means of the solar compass, remarkable variations in the magnetic needle, amounting to 87 degrees from the normal," and that, in 1845, an old

Indian, Chief Mardimesik, living at the mouth of Carp river, piloted a half breed, Achille Cardotte, to a "mountain of ore;" Cardotte, in turn, told of what he had seen to Mr. P. M. Everett, of Jackson, Michigan, and under the guidance of the old Indian chief, Mr. Everett and his party visited the Jackson Mountain and the site of what is now the Cleveland mine. They secured about 300 pounds of ore and "packed" it down to the lake, sending some of it to Jackson, some to Detroit, and a small quantity to Pittsburg. That sent here was pronounced to be worthless, owing, no doubt, to the presence of jasper in the ore, but enough iron was secured from the other lots to make a knife blade for Mr. Everett.

Mr. Everett incorporated the Jackson Company and built a forge on the Carp river, three miles east of Negaunee, in the latter part of 1846, and this forge was kept in operation until 1854; another forge was built at Marquette in 1849, and about the same time forges were built at Forestville and Collinsville, all using the Jackson ore.

The first furnace was built by the Cleveland Company in 1856, using charcoal as fuel, the Jackson Company erecting another about the same time.

In the year 1855 a small dock was built at Marquette, Michigan, and 1,477 tons of ore shipped away by lake. This ore was hauled to Marquette in wagons, and dumped on the dock and transferred to the vessels by the crews. Later a tram road was built and the tram cars were run out on trestles, and the ore was dumped into the vessels from pockets by means of aprons, inclined toward the dock face.

The building of the Sault Ste. Marie "Soo" canal, completed May 21, 1855, attracted the attention of capitalists to the upper peninsula; in 1852 a railroad was projected from Marquette to Michigamme, by the Ely Brothers, who were foremost in the development of the lake trade and the mining industry. They could not complete the work themselves, and in 1856 secured the help of some Boston capitalists, and it was

completed in the latter part of 1857, the road, 40 miles in length, costing \$1,500,000.

The completion of the Soo canal and this railroad stimulated, to some extent, the ore traffic, but the growth was very slow, and not until 1870 did the ore tonnage reach the million mark. In fact, up to 1879, only 11,588,072 tons had been mined, as compared with 12,469,638 tons in the year 1897 and 120,088,178 tons from the discovery of the ore to the close of 1897. This tremendous growth of latter years has created a large fleet of vessels to carry it, and the lake tonnage passing through the Detroit river now equals the combined foreign and coast line shipments of London and Liverpool, the greatest shipping ports of the world.

The following table, showing the distribution of merchant shipping of the United States, as indicated by the aggregate registered American vessel tonnage, at ten year intervals, beginning with 1877, is interesting :

	1897.	1887.	1877.
Atlantic and Gulf Coasts Tonnage.....	2,647,796	2,847,135	2,994,865
Pacific Coast Tonnage	439,012	334,669	251,556
Total Salt Water Tonnage.....	3,086,808	3,181,804	3,246,421
Great Lakes Tonnage.....	1,410,103	733,069	610,169
Rivers	272,109	356,355	436,018
Total Tonnage.....	1,682,212	1,089,424	1,046,187

The lake trade, as shown by vessel tonnage, has increased 92.3 per cent. in ten years, while the salt water shipping has decreased 3 per cent., the tonnage of the Atlantic and Gulf coasts showing a decrease of $8\frac{1}{2}$ per cent. since 1877, and the river tonnage a decrease of 37.6 per cent. since 1877.

This wonderful increase of vessel tonnage on the Great Lakes is very largely due to the development of the ore mines of the Lake Superior region. The capital employed in the mining and transportation of this ore is necessarily very large: Hon. Geo. H. Ely, of Cleveland, a member of the American Society of Civil Engineers, in his paper read before the Interna-

tional Congress at Paris, in 1892, gives the following details as to the capital thus invested :

Capital in the mines in the four Lake Superior districts in 1889, as per U. S. census.....	\$54,825,122	
Increase to July, 1892.....	15,000,000	
		\$ 69,825,122
Capital in docks and their equipment, at Lake Superior and Lake Michigan ports, built and used exclusively for shipping ore (official).....		9,885,665
Capital employed exclusively in railroad transportation of ore from mines to shipping ports on Lake Superior and Lake Michigan (official).....		27,014,594
Floating capital on the lakes, employed exclusively in ore transportation from the Upper Lakes to some lake ports (estimates).....		29,933,107
Capital in docks and their equipment for receiving and forwarding ore, exclusively at Lake Erie ports, between Toledo and Buffalo, inclusive of both, (official).....		12,392,880
Capital employed, exclusively in railroad transportation of ore, inland, to mills and furnaces, from Lake Erie ports (official)		26,343,617
Total.....		\$175,394,985

To this estimate of Mr. Ely should be added the investments, since 1892, in ore-handling machinery and new docks, both on the upper and lower lakes; the new Bessemer railroad, and the great fleet of vessels built by Mr. Rockefeller and his associates, aggregating at least \$40,000,000, and bringing up the total to over \$215,000,000.

I have given this sketch of the discovery and the recent rapid growth of the Lake Superior ore tonnage, which, perhaps, more properly belongs to the paper on "Mining of the Ore," in order to set forth as clearly as possible the conditions which have confronted the carrier, and that you may judge, from the facts presented, how these conditions have been met.

MOVEMENT BY RAIL TO DOCKS.

The ore is transported in self-clearing hopper cars, of a capacity from 20 to 30 tons each, the small four-wheel car of light capacity having about disappeared.

The principal ore-shipping docks are located at Marquette, Escanaba, Two Harbors, Minn.; Ashland, Duluth, Superior

and Gladstone; the docks at St. Ignace and L'Anse being of minor importance, and from which, of late years, no ore has been shipped.

Marquette, Mich., was the first port opened, and its history is contemporaneous with the government surveys of the upper peninsula. The railroad to Ishpeming, known as the Iron Mountain road, was completed in the latter part of 1857. It was extended to Houghton in 1883, to the "Soo" in 1887, and to Duluth in 1888, in which year the line became known as the Duluth, South Shore and Atlantic. The first ore shipments were made in 1856. The longest haul for the ore to these docks is from Michigamme, forty miles, and the shortest, Negaunee, eleven miles.

Escanaba, Mich., is on the west shore of the Little Bay de Noquit, in Menominee County, the northern extremity of Lake Michigan. The Chicago & Northwestern railroad handles the ore at this port, and as the vessels do not have to pass through the "Soo," and thus escape the late and early ice, this port has the distinction of having the earliest and latest shipments of ore that can be made. The first shipments of ore from the port was made in 1865, and it shares with Marquette the product of the mines in the Marquette range.

Two Harbors, Minn.—This port is about twenty-seven miles north of Duluth, and is located upon a natural bay known as "Agate Bay." The first engineering work was begun here in December 6, 1882. The contractor began work in July, 1883, and in one year, in August, 1884, the Duluth & Iron Range railroad, from Two Harbors to Tower Junction and Ely, and from Two Harbors to Duluth, with an ore shipping dock, was completed, showing the energy and push of its promoters. Over these docks are handled Mesaba and Vermillion ores. The railroad crosses the Mesaba range, about fifty miles from the lake, and the Vermillion range at Tower Junction, sixty-seven miles from Two Harbors.

Ashland, Wis., is located upon the shores of Chequamegon

Bay. The Chicago & Northwestern, and the Wisconsin Central both have docks here. The Wisconsin Central was built from Ashland to Penoque in 1873, but the ore docks were not erected until 1886 and 1887. The longest haul for the ore on this road is sixty miles, the shortest forty miles, and the ore is moved in trains of thirty cars, of twenty-two tons capacity.

The Iron Range railroad, now a part of the Chicago & Northwestern system, was opened in 1885, and was the first to handle the products of the Gogebic mines over the docks built in 1885. The longest haul is fifty-five miles, from Wakefield, Mich., and the shortest from Hurley, Wis., forty-five miles. The average train consists of twenty-eight cars, of twenty-two tons capacity.

Gladstone, is located upon the southwestern shores of Lake Superior, on Little Bay de Noquit, and made its first shipment of ore in 1889, handling Menominee ores, and it is reached by the Minneapolis, St. Paul & Sault Ste. Marie railroad.

Duluth.—This port, made famous by the celebrated speech of the Hon. Proctor Knott, is located upon the extreme western end of Lake Superior, and did not become a shipping port for ore until 1892, upon the completion of the Duluth, Mesaba & Northern railroad to the Mesaba Range.

The ore docks of this railroad, when first built, were said to have been the finest and most complete in the world, embodying, in their construction, all the modern improvements, the owners having been able to profit by the experience with docks of early construction.

Superior.—The ore docks of the Duluth & Winnepeg, now part of the Great Northern system, are located on Allouez Bay, and are of the most modern type.



FIG. 1. SHIPPING DOCKS ESCANABA.

The shipping docks (fig. 1) constructed of trestles built on piles, and reached by a longer or shorter approach, depending on the character of the land and the depth of the water in the harbors. The tops of the docks vary from forty to fifty-five feet above the water level, and the trestles are wide enough to take several tracks, which are sometimes built so that the gauge between the tracks is the same as the gauge between the rails, so that the entire top of the trestle can be utilized for dumping the ore. The number of pockets and their capacity vary. ASTOR, LENOX AND TILDEN FOUNDATION The pockets are lined with iron plates, and, of course, slope toward the water side of the docks. There is a door at the bottom, through which the ore is discharged into iron spouts, which are lowered into the vessels' holds, when they are ready to load, and, by raising of the door, the ore runs directly into the vessels. If the proper kinds of ore are at hand in the bins, the largest vessel can be loaded with but little delay. The record for fast handling is said to have been made with the loading of the steamer Fontenac, with 980 tons, in four and three-quarters minutes.

I give below a table showing the dimensions of the ore docks at the various ports, made up from information furnished by the general officers in charge of the railroads operating or owning them. These dimensions differ from those given in Mr. John M. Birkinbine's report to the Department of the Interior, on the production of iron ore in 1891, as the larger boats have forced the railroads to raise their docks and increase their storage capacity.

As an example of what the railroads have been compelled to do, I quote from letter from Chief Engineer R. Angst, of the Duluth & Iron Range :

"We are very peculiarly situated, with our terminals, at Two Harbors. The original docks, Nos. 1 and 2, were built in 1884, with pockets on one side only, single track approach, flat angle in the bottom of the pocket, and with base rail on top of the dock thirty-nine feet six inches above the water.

The yard built in connection with these two docks was only thirty-eight feet above the water. With the increase of business, these two docks were raised six feet, and extended as double docks. Later on, we built docks 3 and 4, and finally, No. 5, to the elevation given. Nos. 3, 4 and 5 are fifty feet wide, compared with forty-one feet of the original Nos. 1 and 2, and as the yard of each new dock, as built, was practically raised to the level of the dock, the yard had to be lengthened accordingly. This involved a great amount of earth work, which, with each new dock, had to be remodeled. No. 2 dock was taken down last year, owing to age and insecurity, and was rebuilt on our standard plans of fifty feet in width, and the dock was raised to fifty-seven feet above the water, and the deck was lengthened out one hundred and ninety-two feet, thus we now have a dock fifty feet wide, and fifty-seven feet high, with a capacity of forty-two thousand tons, as against the old dock, forty-one feet wide, thirty-nine and one-half feet high, and twenty-five thousand tons capacity.

“It may interest your friends, and possibly yourself, to know that the extreme end of dock No. 5 is in forty feet of water, making the base of rail on the dock ninety-four feet above the solid surface in the bottom of the bay. Our switching is mostly done with ninety-two tons consolidation engines; the pockets are twelve feet, center to center of wall; the ore cars are twenty-four feet, center to center of coupling. So you will readily understand that the engine-men are using the air brakes quite vigorously in stopping trains of thirty to forty cars.”

DIMENSIONS OF SHIPPING DOCKS FOR LAKE SUPERIOR ORE.

Location.	Height of Dock. Feet.	Length of Dock. Feet.	No. of Pockets.	Capacity in Tons.	Approximate Cost.	Owned by.
Marquette	No. 1.....45 No. 3.....37 No. 4.....47.3	1,620 1,060 1,300	270 213 200	37,000 12,780 28,000	\$1,200,000	Duluth, South Shore and Atlantic R. R.
Escanaba	No. 1.....48 No. 3.....52 No. 4.....48 No. 5.....53	1,104 1,856 1,500 1,392	184 226 250 232	24,104 30,284 32,750 43,152	\$1,225,000	Chicago and Northwestern R. R.
Two Harbors	No. 1.....45.5 No. 2.....57.0 No. 3.....51.5 No. 4.....51.5 No. 5.....54.0	846 1,248 640 1,008 1,008	141 208 80 168 168	23,900 42,000 16,000 30,000 80,000	\$1,200,000	Duluth and Iron Range.
Ashland	No. 1.....40 No. 2.....54 No. 3.....54.6	1,404 1,404 1,908	234 234 314	20,592 26,036 33,500	\$ 300,000 350,000 800,000	Chicago and Northwestern R. R. Wisconsin Central. M. St. P. & S. St. M.
Gladstone	No. 1.....47.0	768	120	15,000	120,000	Duluth, Mesaba & N. Ry.
Duluth	No. 1.....53 No. 2.....57	2,400 1,800	384 288	109,000 850,000	850,000	Great Northern Ry.
Superior	No. 1.....52	1,500	250	40,500	350,000	

The relative importance of the shipping docks can be seen by an inspection of the table below, which shows the amount of ore shipped from each of the ports, 1892 to 1897, both inclusively: These statistics are taken from the Iron Trade Review of Cleveland.

	1897.	1896.	1895.	1894.	1893.	1892.
Escanaba	2,302,121	2,321,981	2,860,172	1,641,776	2,048,525	4,010,085
Marquette	1,945,519	1,564,813	1,079,485	1,424,850	1,086,934	1,026,338
Ashland	2,067,637	1,586,236	2,350,219	1,788,590	1,117,520	2,223,684
Two Harbors	2,651,465	1,813,992	2,118,166	1,373,253	903,329	1,165,076
Gladstone	311,014	220,887	109,211	79,308	203,585	115,816
Superior	531,825	167,245	117,884	.....	80,273	4,245
Duluth	2,376,064	1,988,932	1,598,783	1,369,252	440,592	.....
Total	12,215,645	9,644,036	10,233,910	7,629,829	5,880,918	5,880,918
All rail shipments	.....	290,792	185,127	118,394	178,037	178,037
Total shipments	.....	9,934,828	10,429,037	7,748,223	6,058,955	6,058,955

Of the shipments of 1897, two million ninety four thousand seven hundred and thirty-nine gross tons were sent to Bay View and South Chicago, and ten million one hundred and twenty thousand nine hundred and six to Lake Erie ports, and it is estimated the all-rail shipments were two hundred and sixty-five thousand tons.

MOVEMENT BY VESSEL.

Prior to the opening of the "Soo" canal, the Lake Superior fleet was made up of five steamers of forty tons each, one of fifty tons, three of seventy tons, and one of one hundred and eighty tons; the propeller Independence and the steamer Julia Palmer, of two hundred and eighty tons each, a total registered tonnage of one thousand two hundred.

As the horse-whim has given way to the elaborate and costly hoisting engine, and the laborer, with his pick and shovel, to the steam shovel in mining, the horse and wagon and the tram road to the steam railways and heavy locomotives and specially-designed cars for the transportation to the shipping docks, so the vessel of light tonnage has given way to the lake leviathans, to the end that the ore may be given to the consumer at the lowest possible cost.

The ore is now carried very largely in steamers or barges belonging to the various mining or dock companies, and the fleet is being added to yearly by a number of large steel vessels of a carrying capacity of over seven thousand tons. Ten years ago the typical ore boats were those of the Mutual Transportation Company, or the Hanna fleet, headed by the Cambria, carrying two thousand five hundred to three thousand tons of ore. To-day these steamers are obsolete, and the standard ore-carrier is the type of vessel represented by the Roebling, the Bessemer and the Morse, four hundred and seventy-five feet in length and fifty feet beam, designed to carry seven thousand five hundred tons on seventeen and one-half feet draft. On August 28, 1898, the Roebling, of the Bessemer fleet, brought down seven thousand twenty-two tons gross, or seven thousand eight hundred and sixty-five net tons, with a draft fore and aft of seventeen and one-half feet. The whaleback, both steamer and barge, or "Sow and Pigs," as they are termed, are also good carriers of ore, but not quite satisfactory for grain or flour. The large vessels have about driven the smaller steam-

ers and sailing vessels out of business, as the smaller boats cannot compete with the large steamers and live.

That you may judge of the results of this fierce competition, I give a few facts as regards ore rates :

In 1867 it cost an average of four dollars and twenty-five cents per ton to carry ore from Escanaba to the Lake Erie ports ; in 1870 the cost had been reduced to two dollars and fifty cents ; in 1894 the average "wild-rate" was forty-six cents, and at times as low as forty cents, the contract rate being sixty cents.

This year the contract price will average forty-five cents from Escanaba, and fifty-five cents from Marquette, and sixty cents from Duluth, the "wild rates" running from forty cents from Escanaba and forty-five cents from Lake Superior ports.

RECEIVING DOCKS.

The principal receiving docks of Lake Erie are those at Cleveland, Fairport, Ashtabula, Conneaut and Erie. Next in importance are those of Buffalo, Toledo, Lorain, Huron and Sandusky.

The relative importance of these ports can be readily seen by an inspection of the tables below, giving the receipts of ore for the last six years, and the storage capacity, as shown by the ore on docks at the close of navigation on December 1 :

IRON ORE RECEIPTS AT LAKE ERIE PORTS, GROSS TONS.

Ports.	1897.	1896.	1895.	1894.	1893.	1892.
Toledo	416,438	301,794	260,730	158,384	145,515	139,987
Sandusky	79,792	58,667	12,361	23,043	4,464	49,736
Huron	198,231	226,515	146,442	172,775	137,775	65,000
Lorain	355,188	191,445	214,219	150,424	165,667	190,400
Cleveland	2,456,704	2,313,170	2,312,370	1,624,573	1,260,716	1,860,224
Fairport	1,006,340	941,446	914,617	976,222	792,517	866,611
Ashtabula	3,001,914	2,272,822	2,474,791	1,987,722	1,845,738	2,535,416
Conneaut	493,327	327,623	244,967	237,906	203,207	1,130
Erie	1,311,526	847,849	811,989	624,438	469,299	645,230
Buffalo and Tonawanda	797,446	545,101	719,742	395,339	308,238	197,000
Total	10,120,906	8,026,432	8,112,228	6,350,825	5,383,136	6,860,734

The opening of the Bessemer road to the Carnegie Furnaces has changed the relative importance of Conneaut, making it one of the most important ports, and the receipts in 1898 will reach about one million four hundred and fifty thousand tons.

IRON ORE ON LAKE ERIE PORTS, DECEMBER 1—GROSS TONS.

Ports.	1897.	1896.	1895.	1894.	1893.	1892.
Toledo	194,614	151,959	113,132	96,157	92,911	71,409
Sandusky	84,786	59,491	34,375	77,004	78,439	87,500
Huron	230,029	200,075	101,000	147,632	89,000	46,000
Lorain	317,509	231,288	224,264	223,732	201,632	147,600
Cleveland	1,478,356	1,419,311	1,200,792	1,441,785	1,163,930	1,347,892
Fairport	825,312	773,906	606,470	660,980	678,083	610,809
Ashtabula	1,835,194	1,441,686	1,301,302	1,439,119	1,096,431	1,312,658
Conneaut	360,896	275,800	292,460	199,365	91,337	.....
Erie	484,871	355,222	335,718	454,238	359,827	401,633
Buffalo	111,660	82,267	207,199	94,238	119,170	125,000
Total	5,923,755	4,990,984	4,415,712	4,834,245	4,070,710	4,149,451

It is unnecessary to give a detailed statement of the characteristics of these docks; the capacity for handling and storing is given in the table.

ORE DOCK CAPACITIES OF THE FIVE PRINCIPAL
LAKE ERIE PORTS.

Ports.	Railroads.	Aggregate Dock Face. Feet.	Machines.			Aggregate unloading capacity per day.	Total storage capac- ity, including trestles.
			McMyler.	Ore Bridges.	Fast Hoists.		
Cleveland	Penna. Lines. Erie. C. T. & V. R. Pittsburgh & Western.	7,200	4	46	12	25,000	1,600,000
Fairport							
Ashtabula	Penna. Lines. Lake Shore.	11,350	19	66	18	37,500	1,350,000
Conneaut	P. B. & L. E.	4,000	3	15	12	13,000	700,000
Erie	Penna. Lines.	4,368	6	13	12	18,000	750,000
Total	All Lines.	32,418	50	137	54	98,500	6,000,000

Cleveland has the distinction of having been the first to receive the Lake Superior ore. It was the natural destination, as it connected by rail with the Mahoning Valley, where there were a few small local stacks working up black and local hematites on the excellent block coal that was mined in this valley.

When this ore reached Cleveland, it was handled with very primitive machinery. A whisky barrel sawed in two, with knotted ropes passed through eye holes bored on each side, formed the bucket into which the ore was shoveled. A block and fall fastened to one of the spars of the vessel, and a horse at the end of the rope was the machine that hoisted it out of the hold ; a wheel-barrow, the bridge for moving it back to storage piles.

Erie received its first ore from the Lake Champlain district. The first ore was received in 1856, and was simply thrown by hand out of the vessel's hold on to the dock, and wheeled back to the storage place, on the public landing, at State street. But in those days there was but little ore to handle, and the price of the ore was such that it could stand the cost of several handlings.

On reaching the docks there are three ways of disposing of the ore.

First. Direct loading into cars for immediate shipment to furnaces.

Second. Unloading into stock piles on the docks.

Third. Unloading into specially-designed cars for carriage to storage trestles.

In former years, it was customary to store a good portion of the ore at the Lake ports, shipping to the furnaces only as required for daily use, but in later years the furnaces have increased their storage facilities so as to be able to take a large portion direct from the vessel, and this year at least two-thirds will go forward direct.

This means a considerable saving to the consumer, but

requires the railroad companies to provide increased equipment to carry in seven months what they formerly carried in twelve. It has enabled them, however, to get along with less storage room at the dock, and thus saved a considerable outlay for additional terminal facilities, which would have been required to handle the increased receipts of late years.

The ore is handled by contractors for the railroad or dock companies, the railroad companies generally owning the ground and sometimes the machinery, for the use of which a rental is charged. In other cases the machinery is furnished by the contractor. The contractor is paid both by the vessel owner and the railway or dock company. It being the duty of the vessel owner to deliver the ore on the rail of the vessel.

The photographs here shown are of the most modern types of machinery used in ore handling. The long and short bridges (Figs. 2, 3, 4 and 5) are used not only for direct loading into cars, but also for storing the ore on the docks.

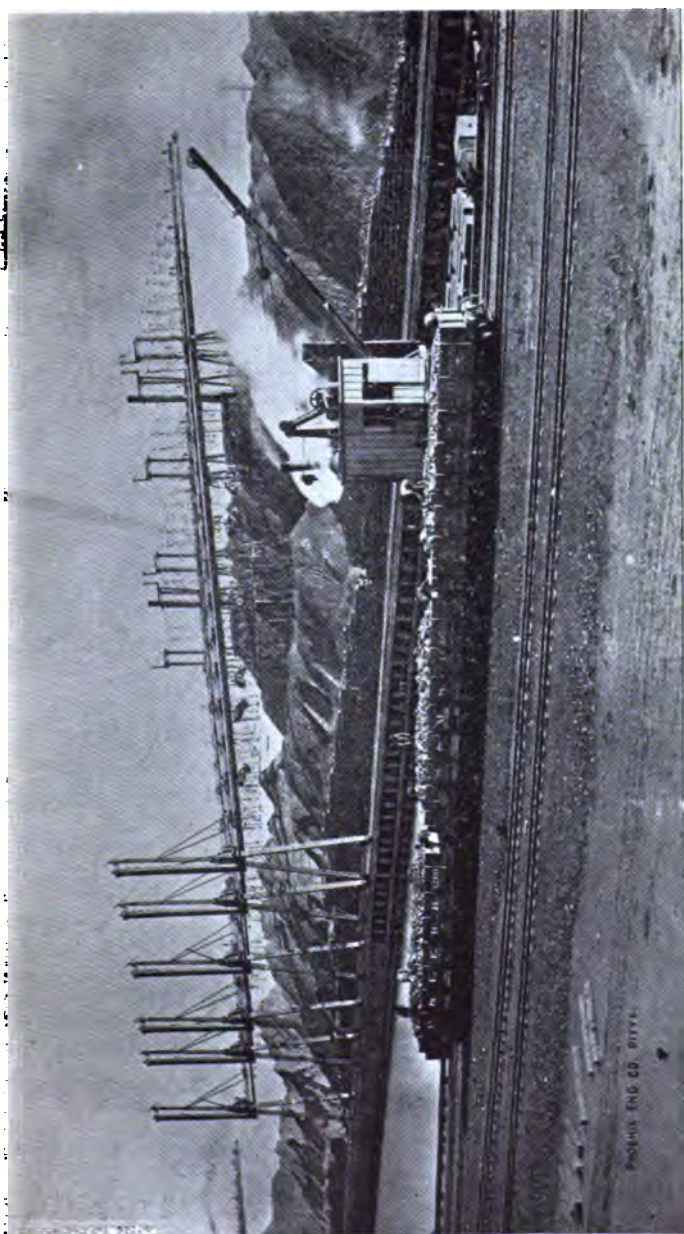


FIG. 2. BROWN BRIDGE FOR STORING ORE.

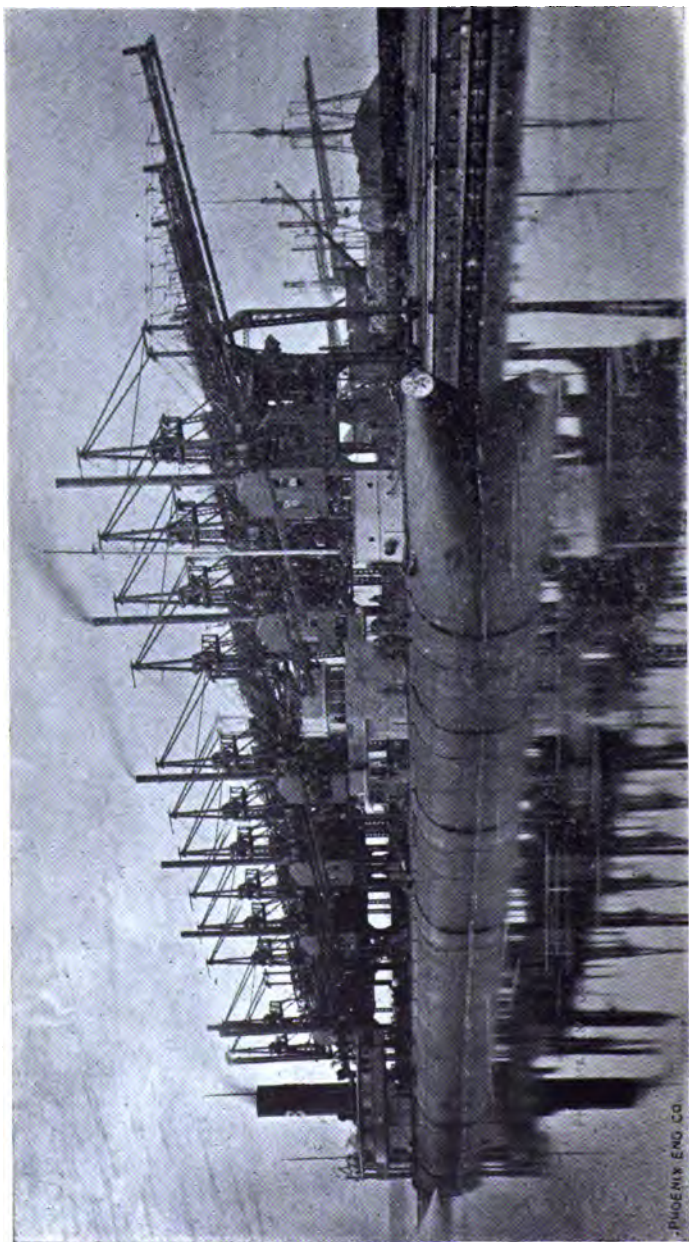


Fig. 3. GENERAL VIEW SHORT BRIDGE FOR DIRECT LOADING AND STORAGE OF ORE.

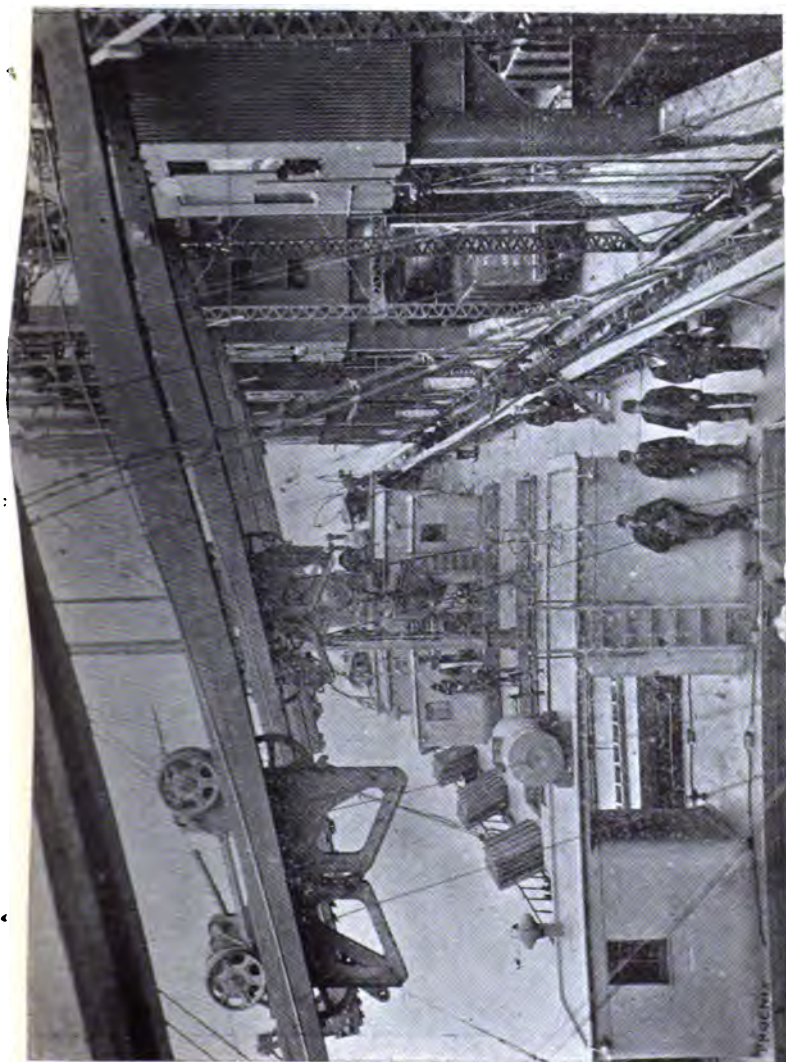


FIG. 4. WATER-FRONT VIEW, SHORT BRIDGE.

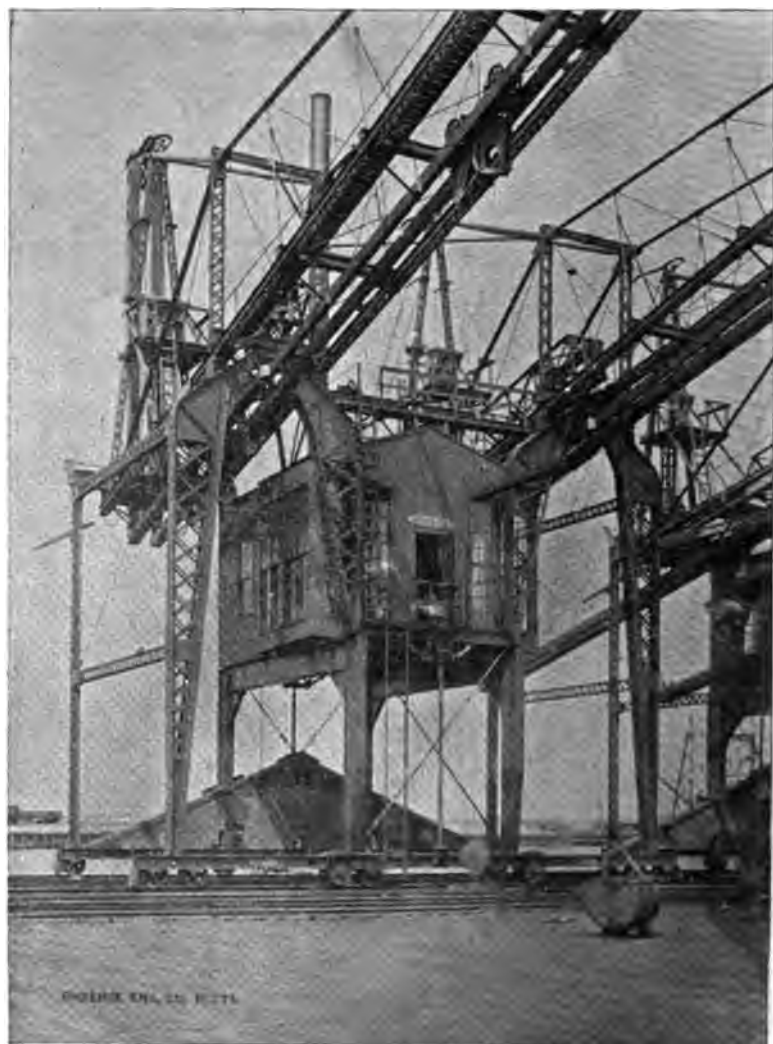


FIG. 5. DETAIL VIEW, SHOWING ENGINE HOUSE SHORT BRIDGE.



FIG. 6. FAST HOIST FOR DIRECT LOADING OF ORE.

The fast hoist (Fig. 6) is used where the ore is all to be loaded directly into cars and the machine shown on preceding page can handle 500 tons per hour, or 5000 tons per day.

When the ore is to be put under storage trestles, side dump cars of large capacity, (80,000 to 90,000 pounds), with three trucks, are used, these cars being much better suited to the work than self-clearing hopper cars.

In loading from stock pile the ore is sometimes shoveled direct into the cars; in other cases it is loaded into the regular ore buckets, and hoisted by the same machinery used in unloading from vessel. In other cases a bucket scoop is used, and steam shovels are also employed. The margins are now so close that every possible economy has to be practiced.

TRANSPORTATION FROM RECEIVING DOCKS TO FURNACE.

The ore is carried in two types of cars, the plain gondola, with loose or fixed ends, varying in capacity from thirty thousand to eighty thousand pounds, and the hopper cars, of a capacity from seventy thousand to one hundred thousand pounds. It is customary to permit a loading of ten per cent. above the marked capacity, so that on some cars one hundred and ten thousand or even one hundred and fifteen thousand pounds of ore can be carried.

The introduction of the large capacity cars has been forced upon the rail carriers, first by the large increase in the carrying capacity of the vessels, which require the same dispatch that was given the vessel of two thousand tons in the early nineties, and, secondly, by the reduction in compensation for carrying the ores to the furnace. It was impossible in many cases to increase dock or track facilities, and reduced earnings made necessary reduced expenses. The first step was the building of cars to carry seventy-seven thousand to eighty thousand pounds of ore, and of the self-clearing type. These cars are shorter than the standard gondola, and as twelve of these cars, carrying nine hundred and twenty-four thousand

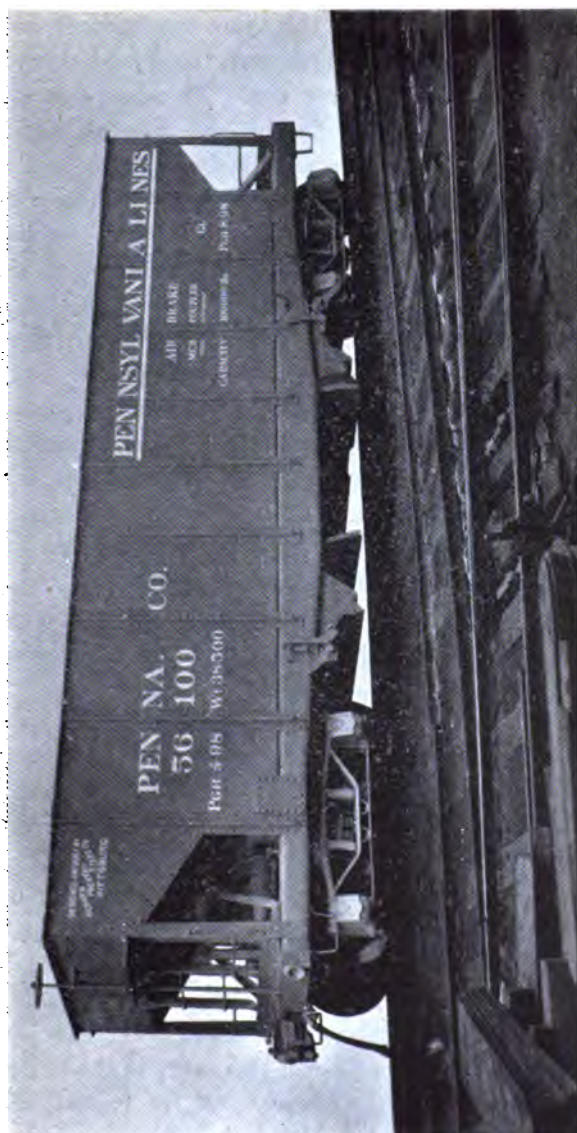


FIG. 7. SELF-CLEARING TYPE STEEL CARS.

pounds of ore, occupy the same track space as ten gondolas, carrying six hundred and sixty thousand pounds, we gained forty per cent. by their use. These cars were soon followed by steel cars, (Fig. 7), of one hundred thousand pounds capacity, and thirty-one feet in length, and as these cars will carry safely one hundred and ten thousand to one hundred and fifteen thousand pounds of ore, we have an advantage of sixty per cent. over the standard sixty thousand pound gondola, and the furnace owner has the advantage not only of getting his ore in a self-clearing car, thus reducing the cost of labor in unloading, but he can get forty to sixty per cent. more ore on the same track, and thus is saved the expense of increasing his track facilities to meet increase in his production of pig iron. Of course, he must increase his storage trestle to get the full benefit of the economies, and the railroad company must spend more for their one hundred thousand capacity cars than they did for the sixty thousand capacity car, but the cost of maintenance is no greater, and the light weight not proportionally greater in comparison with increased carrying capacity.

The introduction of the large car has compelled the building of larger locomotives, (Fig. 8), and the reduction of grades. In some cases the reduction of grades has not been possible, and the only economy effected has been the introduction of large locomotives.

The improvements of the last ten years have been very marked, and ore is being handled at a cost for labor from its natural state in the ground to the furnace stack that twenty years ago would have been thought impossible. To this the ore itself has largely contributed. The extended use of steel in the great lake and ocean steamers, in the larger locomotives, in the ore car, in the heavier rail, in various structural materials, has been made possible by the discoveries of rich ores that can be cheaply mined, and when ore is loaded on cars at a cost of four cents per gross ton, the mining cost is down al-



FIG. 8. STANDARD LOCOMOTIVES USED IN TRANSPORTING ORES FROM LAKE PORTS TO FURNACES, 1888 AND 1898.

most to the vanishing point. It is true, also, that the furnace manager has done his part in reducing cost by improved methods and better machinery, details of which will no doubt be set forth in a future paper before this Society. The tendency of the times is to give the consumer cheaper and better articles, and in nothing is this more manifest than in the production of iron and steel.

DISCUSSION OF MR. TAYLOR'S PAPER.

PRESIDENT—When I first spoke to Mr. Taylor about this paper, several months ago, he seemed to think that he could not get up very much of a paper on the subject. I am happy to say that, on second thought, he has seen fit to change his mind, and has given us a most comprehensive paper, and one which perhaps will, as much as anything that will be published for some time to come, serve to show to the residents of this community what a wonderful locality it is in which we live. It has certainly emphasized the great extent of our chief industry.

MR. TAYLOR—This photograph is of one of the steel hoppers which I referred to. The car was built for the Carnegie interests last year. The cars which are now being built for the Pennsylvania lines are still larger and heavier, with larger journals. The journals of this car are five by nine inches, and those now being built are five and one-half by ten inches.

MR. DAVISON—Since the cars and engines were built which are shown in the photograph, still larger cars and engines have been built. Mr. Taylor, what is the weight of that one?

MR. TAYLOR—The light weight is thirty-four thousand pounds; that of the new one is between thirty-eight thousand and thirty-nine thousand pounds. The weight of the new engine is, two hundred and fifteen thousand pounds.

MR. DAVISON—The weight of the last locomotive built for the Union railroad, including water and fuel, is about three hundred and thirty thousand pounds ; weight on driving-wheel, twenty thousand eight hundred pounds. This is the latest acquisition to the equipment for transporting iron ore to Pittsburg furnaces. It is the largest locomotive ever built.

MR. CAMP—The Pennsylvania railroad car differs considerably from that of the Lake Erie, does it not ?

MR. TAYLOR—Yes, it is wider ; we have loaded on the new cars as high as one hundred and eight thousand pounds of coal by rounding the coal up. This not only made the coal look better, but gives the railroad company greater tonnage per car. The operator is willing to trim the coal because when cars are scarce he gets an increased modudem for his mine.

MR. DAVISON—What is the length of the new car ?

MR. TAYLOR—Thirty-one feet six and eight-tenths inches. It is undoubtedly to the interests of the railroads in this section to use steel cars. The more steel that is used, the greater the demand for ore. The idea of the Carnegie interests in building their first steel cars was to secure greater use for their products.

MR. CAMP—A car of that description would be a nice thing in a wreck.

MR. TAYLOR—I have some photographs showing the effects of a wreck in the yard where the cars were built. The car that was damaged to the greatest extent required repairs amounting to thirty dollars.

MR. CAMP—How badly was it wrecked ?

MR. TAYLOR—The photograph shows that. We have had no very serious wrecks yet with these cars, although we have used the cars extensively for over a year.

MR. DAVISON—You do not have any wrecks on your line, do you ? (Laughter.)

MR. TAYLOR—If we do not, I do not think it a wise thing to say so. I have heard of a superintendent who boasted of never having any wrecks, and the words were hardly out of his mouth before a telegram was handed to him announcing a bad one.

MR. CROOKER—Do you know what the average life is of the regular wooden gondola car?

MR. TAYLOR—From eighteen to twenty years.

MR. CROOKER—Does not the wood-work rot in much less time than that?

MR. TAYLOR—Of course there is always more or less repair work being done, and parts are being renewed from time to time.

MR. DAVISON—It is my opinion that the cars are practically rebuilt at least once during their term of service.

MR. CROOKER—Is it not a fact that within eight or ten years the larger portion of a wooden gondola car is as rotten as punk?

MR. TAYLOR—It ought not to be so. I do not think there is any doubt of the life of the wooden car being about eighteen years if it is kept in good repair. The trouble has been that the wooden car has not had sufficient capacity. The constant demand is for cars of greater capacity. But by spending forty or fifty dollars on an ordinary gondola car, its life may be prolonged for several years, but it would often be too light for general use, and cars are therefore cut up, not because they are worn out, but because they are obsolete.

MR. CROOKER—I brought this question up to learn whether or not we could presume a much longer life for the steel car than for the wooden one, but, if the wooden lasts eighteen years, the question is still an open one. I was under the impression that the wooden car became quite rotten in eight or ten years. What do you consider will be the life of the steel car?

MR. TAYLOR—That is a hard question to answer, but I should say, based on the experience in Europe, forty years.

MR. DAVISON—What is the cost of the steel car ?

MR. TAYLOR—About two cents per pound.

MR. DAVISON—Then it is almost fifty per cent. greater than the cost of the wooden one.

MR. TAYLOR—I think a wooden car of the same capacity would cost about one hundred dollars less than the steel car.

MR. CROOKER—Is not two cents per pound a little low ?

MR. TAYLOR—It may be that it is a little low. The work is mostly machine work, but perhaps two and one-fourth cents per pound would be a little nearer the actual cost, competition however, will bring down the cost.

MR. DAVISON—There is one other commercial factor that must be taken into consideration, and that is that the lumber which enters into the wooden car is becoming scarcer and more expensive every year, and that is the reason why we must look to the steel construction of cars.

MR. CAMP—What is the weight of rail used on these roads ?

MR. TAYLOR—Seventy and eighty-five pounds per yard. From what I can learn, the seventy pound rail is giving better satisfaction, generally speaking, than the eighty-five pound ; and the eighty-five pound than the one hundred pound rail.

MR. FESSENDEN—You spoke in your paper of the whale-back not being useful for grain carrying.

MR. TAYLOR—I have been informed by lake men that such is the case. It seems that in working under strain, water sometimes gets in, and, for that reason, it is not considered a first-class vessel for the transportation of grain and flour.

MR. DAVISON—I think the society owes Mr. Taylor a

vote of thanks for his very interesting paper, and the Program Committee should be congratulated for providing such an excellent series of papers for the coming winter.

Upon motion, the meeting adjourned, and the members partook of a lunch which had been provided by the Reception Committee.

REGINALD A. FESSENDEN,
Secretary.

MEETING OF CHEMICAL SECTION.

PITTSBURG, October 20th, 1898.

The regular meeting of the Chemical Section was held October 20th, 1898, in the rooms of the society.

CHAIRMAN J. O. HANDY presided.

Attendance, 17.

The minutes of the last regular meeting were read and approved.

MR. J. M. CAMP reported that the Board of Direction had considered favorably the request of the Chemical Section for renewal of subscription to the *Chemiker Zeitung*.

MISS MARY L. LYNNE read the paper of the evening, on "Garbage Disposal in Pittsburg and Elsewhere." The paper was discussed by Messrs. Handy, Walker, Stahl and others. (The paper will not be published.)

On motion of Mr. Camp, a very hearty vote of thanks was extended by the Section to the writer of the paper for the able manner in which the subject had been treated.

The Section adjourned at 9:40 P. M.

A. G. McKENNA,
Secretary C. S.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The regular monthly meeting of the Engineers' Society was held in the Lecture Room of the Society's house, Tuesday evening, November 15, 1898. The meeting was called to order at 8:25, the President, Mr. Geo. S. Davison, being in the chair, and fifty-three visitors and members being present.

The minutes of the previous meeting were read and approved.

For the Board of Direction, the following gentlemen were reported as passed, and to be voted upon at the following meeting :

- HARRY P. DAVIS, - Electrical Engineer,
with Westinghouse Electric & Mfg. Co.,
Pittsburg, Pa.
- GEO. W. NOCK, - - Engineer, as Engineer of Works,
Westinghouse Electric & Mfg. Co., Pittsburg,
Pa.
- SAMUEL PETERS, - Metallurgical Engineer,
with Pittsburg Reduction Co., New Kensington,
Pa.
- LAWRENCE C. PHIPPS, Second Vice President and Treasurer,
of The Carnegie Steel Co., Ltd., Pittsburg, Pa.

For the Reception Committee, it was announced that a smoker would be held December 17th.

The President then called the attention of the members to the fact that while the Society was never in such good shape as at present, there were not less than \$1,200 of outstanding dues; that the Society had been making extensive improvements in the Library, and he considered the amount of outstanding dues larger than was proper, but he trusted that the members would do what they could toward getting some of

these dues paid, which would give the Society a handsome surplus.

It was then voted that the President appoint the regular Nominating Committee, and the following members were appointed by the President: Messrs. Ralph Crooker, Jr., Chairman; W. E. Garrigues, and Charles G. Schade.

It was then voted that the Reception Committee be directed to make arrangement for the annual banquet.

The paper of the evening, entitled "Cast Iron," was then read by Dr. R. G. G. Moldenke.

CAST IRON.

BY DR. R. MOLDENKE.

(Consulting Metallurgist, with the McConway & Torley Co.)

The recent tests of cast iron columns, made under the auspices of the building department of New York, brought out very forcibly our comparative lack of knowledge and skill in handling a material which should be peculiarly well adapted for this class of work. The practical condemnation of cast iron for even the simplest of structural members under stress, is the natural consequence of the uncertainty existing in the mind of the engineer and founder regarding the interior condition of an otherwise good looking casting.

In carrying out the numerous processes incidental to the preparation of steel shapes, from the furnace to the erecting shop, a continuous watch may be kept upon the behavior of the metal, imperfections detected with some degree of certainty, and such material at once removed. With cast iron, however, we are practically in the dark, and must depend upon our best judgment and experience. The reason for this state of affairs lies in the great lack of homogeneity in cast iron, this being all the more noticeable as, unlike steel, it is not subjected to subsequent treatment which, if properly carried out, should remove internal strains and leave the piece amenable to the laws of applied mechanics.

But for the manifest advantages of a material which can be cast into any conceivable shape readily and with a fair chance of success, where would a factor of safety of 20 be tolerated? We are hardly ready as yet to accept machinery built of structural steel, as long as the superior stiffness of heavy cast iron frames and beds is not counterbalanced by too great a cost. This, moreover, in spite of the fact that we have to reckon heavily with the internal strains and consequent warping tendencies of large castings in machine design and construction.

The modern tendency is to raise the elastic limit of the materials we work with, in order that a saving in weight may be effected. Note the astonishment of European engineers when they see our bridges and structural work in general. They call it airiness, and lack of solidity; we, on the other hand, deal with the highest grade of materials and keep the standards at the top notch. There is wisdom in this economy, for greater care bestowed upon smaller quantities leaves us the more of our natural resources to draw from in the desperate grapple for the world's industrial supremacy. Thus cast iron is being studied more than ever, its strength is being raised by changes and improvements in processes, and there is on the market to-day a range of irons from the brittle sash weights, which utilize all that would be dangerous in important work, up to the finest gun metals, and those irons which approach the regular steel castings in many ways.

Very little need be said about the history of cast iron. As a matter of fact, the rate of progress in our days is so great that we can hardly pause to look back, being fully occupied to keep at least abreast of the times, if we are not fortunate enough to be in the lead. Suffice it to say that the earliest attempts to cast iron as such were made in England and date back to the 14th century. As the value of everything in those days hinged upon its availability as an instrument of active warfare, we naturally read of the casting of cannon regularly

two hundred years later. Our own Carnegie Museum contains two very interesting relics of cast iron made in the days of William Penn. From England, the art of casting iron spread over the continent and finally came to America.

Until recently, but little attention was given to the general run of foundry work. Iron was very expensive and requirements were not at all severe, specifications being practically unknown. To-day this is different. Competition has put everyone on the alert; every point is noticed, and the small economies practiced for centuries in the old country are now being thought more of here since the rich cream has disappeared from what was formerly a happy-go-lucky business. To-day we are on the threshold of a more rational system of working, our practical men giving their best efforts to improve molding and casting methods, while the scientific end of the trade is making the production of castings a distinct branch of the metallurgy of iron.

According to our general understanding, cast iron is that form of iron which contains more than $1\frac{1}{2}\%$ carbon, and from its nature can only be cast into molds to be of commercial value. A closer examination shows us some limitations to this definition. A thin bar of ordinary cast iron can, under suitable conditions, be heated in the forge and then twisted, thus showing a property at variance with our intuitive feeling of what cast iron should do. Again, many street railway gears are sold as steel because the teeth can stand considerable punishment before breaking, and yet the iron is only an excellent grade of gun metal which has received the additional benefit of some annealing.

Cast iron in its true sense, is, therefore, best classed as that grade of iron carrying over $1\frac{1}{2}\%$ carbon, which, after casting, is not subjected to further heat treatment. Thus pig iron is a true cast iron, for the metal, as it comes from the blast furnace, if of the proper composition, could be used for the direct casting of certain kinds of work, such as ingot

molds. Malleable cast iron, however, is not a true cast iron, for though the casting process is used, the original refining and subsequent annealing, with its radical metallurgical changes, place this most interesting material in a separate class entirely distinct from both cast iron and cast steel.

We have a variety of cast irons, made by a number of processes. Thus the same metal, melted in different ways, produces differently constituted castings, with a consequent variation in commercial value. This will be seen more fully in the discussion of the processes.

To look first at the material the founder of cast iron must deal with, we find an astonishing variety, all of which are useful in their proper sphere. In general, they are the pig irons and the scrap. The scrap may be classified into the foreign (so called because it is bought in the open market), and the gates, sprues, defective castings, and the like, made by the founder himself, the composition or quality of which he may be supposed to know. In the foreign scrap, there are varieties and variations. We have heavy and light machinery scrap, car wheel, stove and miscellaneous scrap, burnt grate bars and the like. The designation usually gives a clue to the quality, which is supplemented by breaking and examining fractures, but taken all in all, without a thorough knowledge of the possibilities of the methods used in mixing and melting charges containing this material, disastrous results are very apt to occur. This is especially the case with the miscellaneous scrap, which may contain the remains of many a burnt out grate bar melted over again, material which should not be taken as a gift when making good work.

The pig irons may be looked upon from the following standpoints. Depending upon the fuel used to make them, they are cold or warm blast charcoal, anthracite, and coke. It would be infringing upon the subject of the blast furnace to go into a detailed discussion. Suffice it to say that anthracite irons are now a rarity, and differ little from those made with

coke. The charcoal irons are too expensive for use in anything except high class specialties.

The experience of the writer, so far as the relative value of coke and charcoal irons is concerned, runs about as follows : The cold blast charcoal iron is probably the finest variety made, and taking irons of identical composition for comparison, the charcoal pig is undoubtedly the better, for the apparent reason that in its preparation the chances of oxidation and consequent weakness have been at a minimum. This point may be disputed, for there is too little known about the molecular constitution of both irons to be positive about any statement concerning them. The fact remains, that if the additional safety derived by the proper use of charcoal iron counterbalances the increase in cost, it is to be preferred. To the credit of well-made coke iron, be it said that this condition exists only in special lines of work.

The second way of classifying pig irons is one rapidly getting out of date, and that is by their fracture. Any one familiar with the variations in fracture produced by higher or lower casting temperatures, would be little inclined to buy iron on this basis. Long experience and familiarity with the iron may give an inkling as to the quality of the metal, just as a steel expert can detect much of value from the fracture of a broken forging. But pig iron must be remelted, and many of its characteristic points seen in the fracture disappear in the casting made from it.

The commercial grades of soft, medium and hard, No. 1 to 6 ; the special grades of foundry, forge, silvery, and mottled irons, as analyzed by a chemist in the shape of an Irishman with a sledge, are being gradually merged into plain pig iron carrying so much silicon, sulphur, phosphorus, manganese, and total carbon.

The range of pig irons, therefore, with which we deal to-day, are either high, medium or low, in their constituents other than the iron. For current use, it is still convenient to

speak of "Bessemer" iron, which for the foundry means phosphorus below .1%, low sulphur and medium to high silicon; "softeners," which mean silicon between 4 and 8%; and "ferrosilicon," which means 8% silicon and above.

The foundry pig irons proper give us the choice between the following compositions: Phosphorus, from .07 to 2.00%; silicon, .14 to 3.25%; sulphur, .02 to .15%; manganese, .30 to 2.00%, and total carbon from 2.50 to 4.50%, the proportion of graphite and combined carbon going to make it up, depending entirely upon the heat conditions and the amount of silicon, sulphur, manganese and phosphorus,—important in the order named—which may be present. One can readily see that, with the limits above given, there may be an endless series of combinations, and when it is remembered that to be able to predict successful results, as required nowadays, as well as to attain them, close attention must be given to this matter, and the lot of that founder who does not believe in chemistry, or rather, metallurgy, in his works, will eventually become a hard one.

We come now to the process for making cast iron. For the production of castings on a commercial scale, there are practically only two: melting in the cupola or shaft furnace, and melting in some form of the reverberatory furnace. The use of crucibles for melting may still be found in experimental work, and possibly in some remote corners of the earth where civilization has not yet given the inhabitants the means of scraping together more dollars, in a given time, by legitimate means. Yet this crucible process is the one calculated to give the cleanest iron. We see this by analogy with crucible steel. The open hearth process can make a material exactly like that from the crucible in composition, yet the latter is so much better on account of its freedom from slag and oxidation. The chemical processes have more time, and the last traces of slag rise to the top.

In the reverberatory furnace, often called the straight draft, we have first the melting down of the charge, the rab-

bling or poling to mix it well and possibly help to clean it, and the slight refining, called for by the work or else unavoidable while getting the proper casting temperature. It may be taken as a safe rule to let this refining action be as limited as possible, for the change is internal, it burns out the manganese and silicon in the interior of the bath, distributes finely divided slag, and makes dirty iron, if sufficient time is not given after tapping to let it clear itself, at best an uncertain proceeding.

To look at the matter more closely, we find first in the charging, the cause of much subsequent trouble. Where the furnace can be charged while hot, that is, where the scrap is no larger than can be gotten through the ordinary sized doors, it is comparatively easy to arrange melts so that the material easiest fused goes in first and forms a bath for the protection of that charged thereafter. The small scrap would therefore go in first and the pig iron last. To help matters, in case the iron is cleaned before charging, slag may be thrown in, which, when melted, forms a protecting coating on the iron, and thus partly arrests the refining action of the oxygen passing over it.

This coating of slag, however, is by no means a complete protection, for the internal action keeps the bath in motion, fresh particles of iron become exposed, through the slag, manganese and silicon are burned out, which, uniting with the oxidized iron, form slag. If the temperature is high, even carbon will go.

Thus it will be seen that there will always be more or less oxidation, with all the troubles that follow from the very nature of the process, and founders of heavy castings, which must be absolutely free from the surface's blemishes, caused by gases in the iron, find this very oxidation one of their worst enemies. The logical conclusion would be to melt as fast as can be done without overheating the charge, and when the iron is properly melted and hot enough to cast, let no delay keep it in the furnace, subject to the oxidizing influences of the flame. When heavy scrap is to be used, and the end of a cold furnace

is taken out for the purpose of charging, one can readily see that the troubles of the founder are aggravated if anything, for the time of melting down a given weight is doubled or trebled.

So much can be said of the behavior of cast iron in the reverberatory furnace. The fact that the metal does not come in direct contact with the fuel (in the crucible method not even with the flame), keeps the product purer, and hence makes the metal (when good) of high grade, in spite of the unavoidable slight oxidation. Another factor in the comparison of cast iron made in this way with that made in the cupola, is the molecular constitution of the respective products. Here we know too little as yet, but this can be said, that a gun cast from refined air furnace iron is undoubtedly better than when cupola metal of exactly the same composition is used. In every day parlance, the last mentioned iron would be judged to be of a "closer" structure than the first, but what that would mean translated into the language of science remains as yet one of the mysteries of molecular physics.

In the cupola process of melting iron, we have a direct contact of the metal with the fuel. Under proper conditions, the oxidation of the iron itself should be less, for that which is unavoidable falls to the manganese first, this uniting with sulphur and protecting the silicon in some measure, the silicon going next. While, therefore, a cupola charge should contain about 15% more silicon than the castings wanted, when there are high manganese pig irons present, or many scrap car wheels, this loss in silicon may drop to 5%, and even less. Carbon, as a rule, remains stationary, and may even go up by absorption from the fuel, 4.60% being about the limit under ordinary conditions.

One of the principal sources of danger is the sulphur in the coke. Too much care cannot be given to keep this as low as possible, and many a casting which failed unaccountably may be found full of microscopic cracks due to the absorption of this sulphur by the iron passing over it, resulting in an

effect well expressed by the current term "red-shortness," were it steel instead of cast iron. The bulk of our castings are made by the cheap and convenient cupola method. It is still crude, in spite of many attempts to use the surplus heat now lost. It will fall to the lot of another to go fully into the status of foundry practice, this much being given with the view of showing to what influences the iron in the castings we buy has been exposed before pouring. Much more could be said, but we must pass on to the next subject, which is the constitution of cast iron.

It is practically impossible to speak of the physical without taking into consideration the chemical properties of cast iron, and *vice versa*. A casting freshly broken may be either gray, white, in a condition running between the two, called "mottled," or it may be gray in the center, then mottled and finally white at the edges. Again, the fracture may show a distinct line separating a gray center from the white chilled rim, as in car wheels and chilled rolls. All of these conditions, whether produced naturally or otherwise, are dependent upon the composition and the thermal changes.

Then we have the crystalline structure, similarly affected. Thus the crystals at the edge of a casting are usually small, and in the harder irons may be seen arranged in layers perpendicular to the surface, causing planes of weakness at abrupt changes in direction on the part of the piece. The interior of the casting, if thick, has larger crystals, and is consequently weaker than the skin. This holds true only if the casting-strains in the piece are not excessive, otherwise we may have the casting in a state of tension such that a comparatively small additional load causes it to give way, the true explanation for many a mysterious failure.

To get rid of such casting-strains in the production of work to be finished up true, very heavy cuts must frequently be taken off. We are all familiar with the strains in pulley arms and rims, and it was the writer's good fortune, in a

western mining region, to see an immense sheave for rope haulage, which had just been taken out of the foundry to clean up, break, at the junction of those spokes with the rim, where the heat of the sun, shining on part of the wheel, had added the very slight tension necessary to cause the wreck.

Where irons are cast into chills, these casting-strains are increased enormously, as, for instance, in making chilled rolls. We have here a thick shell of chilled iron contracting upon a gray interior. The ends of the rolls being smaller in diameter than the body, a period will be reached in the cooling, when they solidify, leaving the interior of the roll still plastic if not fluid. The amount of contraction of a white iron, from casting to coldness, is about one-fourth inch to the foot, while gray varieties show up only half as much; hence we have an enormous pressure exerted upon the interior of such a roll, which, according to discoveries made in subjecting small bodies of high carbon cast irons to such pressures, should make it a genuine mine for microscopic diamonds.

In looking at the structure of cast iron as it appears to the eye, we have its color run from white to very dark gray. This is a question of the condition of the carbon present. For simplicity, we will say that in white iron the carbon is all combined with the iron in some way; in gray iron it is nearly all mechanically mixed with it, and it may be mixed and combined in varying proportions in the irons, between the dead white, and the extra dark gray. The reason for such an appearance may be looked for in the resultant of three variable conditions: the composition, the casting temperature, and the rate of cooling. As to composition, silicon is the most powerful element acting upon the carbon. Its absence keeps the carbon all in the combined state. As it enters into the composition, the tendency on the part of the carbon is to separate out as graphite, this going on until, at nearly 4% of silicon, the reverse takes place, the iron becoming whiter, though of a different crystalline structure and color, giving the "sil-

very " appearance to remelted softeners and ferrosilicons. In these high ranges, the property of silicon to replace carbon, to some extent, gives us lower carbon irons.

As before stated, sulphur, manganese and phosphorus have the same tendency to promote the formation of combined carbon, though in a smaller measure. The physical structures are also different from those produced by silicon, notably, the difference in the chill line and in the crystallization of the chilled iron, due to high or low sulphur with the same low silicon. The casting temperature is of great importance in this connection, the general rule being laid down that the hotter the iron, the greater the likelihood to attain a whiter fracture. Thus one iron may be white if cast very hot, and gray if cast colder. The rate of cooling comes in here. The thicker the piece, the slower it will cool, so that if a wedge were cast of hot iron, the thin edge might be white and the thick end gray.

One can readily perceive what a delicate matter it sometimes becomes in casting very heavy work, with great variations in the thickness of the sections, to so combine the irons that a composition is obtained which, when hot enough to properly run into the thin webs and ribs, will not become white, or at least not hard enough to cause undue contraction and make machining impossible. The fact that the physical condition of a casting is a resultant of these three variables, is often lost sight of by those who write papers and are familiar with the laboratory end of the foundry only. Too much stress cannot be laid upon the absolute necessity of being fully equipped with a practical knowledge of the essentials of founding iron before venturing to advise others upon its metallurgical end.

If we look closely into the character of the various forms of cast iron, as revealed by their microstructure, we find that in the gray irons a polished and etched surface is filled with thin veins of graphite. These are especially distinct when the

etching is heavy, and show us that between the crystalline groups of iron, there are thin lamellae of this very weak material. The rupture of a piece of gray iron is therefore along these planes of weakness, and the thin plates of graphite covering the iron crystals hide them from view. A thorough application of the scratch brush will quickly change a gray iron fracture to a white one, though the structure, unlike a genuine white iron, is coarsely crystalline. The application of acids for etching, and very weak solutions of chemicals, which color the iron and its carbides differently, show, moreover, that surrounding these planes of graphite are carbides of iron, from which it was evidently frozen out.

The heavy etching, necessary to study samples of gray iron, makes it difficult to see much, in fact, in the study of steel and iron, microscopists deplore the lack of illumination, which would allow them to use their highest powers. Here is a problem for the physicist—to furnish a method of illumination, something on the principle of the megaphone in sound. Microscopic investigation on iron and steel requires a vertical reflected illumination, as the specimens cannot be made translucent, and oblique reflection promotes incorrect ideas. Can light be so intensified, without undue heating, that we can apply objectives and eye-pieces, giving us an enlargement of 9,000 diameters, instead of only 1,000 attainable at present, with any degree of confidence in the results? Could science only reveal to us a method by which we can see the molecule, what a wonderful stride this would be!

The appearance of the white irons, under the microscope, is quite complex, the high percentage of carbon in solution obliterating many of the characteristic forms seen in steels. Much is still to be done in this line, and the comparatively high percentages of the various impurities in cast iron, should make this an interesting field. One thing is patent, and that is, the extreme lack of homogeneity in cast iron. One might say that we have nearly pure iron; iron saturated with carbon, in

the shape of several carbides ; iron saturated with sulphur, with phosphorus ; possibly alloyed with maganese and carbon, or with maganese and phosphorus ; iron with silicon, and so on, all these mixed up in a heterogeneous fashion, though with some pretense of arrangement, based upon their relative freezing points, and the rate of cooling fixed by the thickness of the casting and the nature of the mold.

To this comes the additional complication in the existence of all the constituents in two or more forms. Thus phosphorus is present in two very distinct forms in steel, where they can be readily separated by chemical means, and give very different properties, as the one or the other predominates. In cast iron, where the phosphorus contents may be up to twenty times the Bessemer limit, one can readily look for puzzling conditions. Again, the positions of these deleterious ingredients have their effects, more especially, the sulphides present. Sulphide of iron is weak and brittle. It does not diffuse evenly, but rather localizes itself. This may be the cause of some good, now and then, for a high sulphur casting is very dense and impervious to gases, though it is not too strong. It would seem that in the contraction after casting, the sulphide of iron, which has a low melting point, is forced inward by the outer shell, which is setting. This can readily occur, if the casting is thick enough, and, in fact, may save it from destruction, as the giving away of the fluid sulphide eases up the casting strains considerably. In view of the diffusive properties of some sulphides of iron, this otherwise highly objectionable impurity may have some use, after all. If the veins of sulphide of iron present run along the line of stress applied to the casting in service, its presence will not be noticed specially, but if across it, then a real danger exists. Unless, therefore, special effects are desired, as in ammonia, air and hydraulic cylinders, sulphur had better be conspicuous by its absence.

Cast iron is subject to two further troubles, which have a

distinct bearing upon its general behavior. They are segregation and shrinkage. In the first, we meet a state of affairs, perhaps a little more aggravated than in steel, for the rate of setting of heavy bodies of cast iron is slower, and consequently, more opportunity is given to the impurities to segregate and, therefore, impair the casting. Thus the total carbon in the center of a casting may occasionally be less than in the surface, while manganese, and especially phosphorus, may be segregated in very large quantities. Indeed, the separating out of graphite in cooling, is really a segregation.

As the fluid iron sets, it first expands and fills the mold, then as it cools, it contracts, the net result being a slightly smaller volumnar space occupied in the mold. As a direct result from this contraction, the liquid iron is drawn to the setting surfaces, and more fluid metal must be fed in until the whole mass is solid. Should, for any reason, the supply of fluid metal be cut off, as, for instance, a thin section in setting cutting off access to a thicker one, there are bound to be unsound spots, called shrinkages, with consequent dangerous conditions. The very fact that they are seldom observed on the surface, unless, indeed, so bad that this dishes in, makes the testing of all castings calculated to resist the penetration of water or gases absolutely necessary.

These shrinkage spots are sometimes very beautiful, being lined with a glittering array of many colored pine-tree crystals, grouped about in most fantastic figures. Necessarily, white irons, with their great contraction and quick rate of setting, are especially subject to this difficulty, and special means must be resorted to to palliate, if not correct, the evil. The usual way is the application of a chill to the spots most likely to suffer.

We must, therefore, distinguish between the shrinkage in a casting which is internal, and its contraction, erroneously called shrinkage, also, which is external, and is allowed for in the pattern. There are some points in this matter which

require further study. As a casting cools, the graphite already having separated out, there is a change in the carbon remaining combined, comparable to recalescence in steel. Whether this causes further marked disturbances in the size of the casting, is a much mooted question, evidence on both sides being in. It has appeared to the writer that the apparatus used by all those who have experimented in this line, was too crude for the delicate observations which must necessarily be conducted. He, therefore, recommends the use of mirrors arranged to move with the cooling metal, and rays of light reflected from them upon bromide paper moving at a given rate of speed. This, if properly carried out, should give a sufficient enlargement, without any friction of moving parts, or absorption of minute movements in the mass of the apparatus.

A further difficulty to which many a failure to obtain sound castings may be laid, is the presence of gas in the iron. This manifests itself by coming out at the moment the metal sets. If it can get away through the mold, well and good; if not, a smooth-walled aggravating hole, just under the skin, and often defying detection, is the result. The trouble may be laid to the handling of the furnace or cupola, the use of burnt material, and probably what is least suspected, the tendency of late years to produce pig irons too fast, with the resulting liability of oxidizing them slightly.

The peculiar shrinkages in iron are closely related to the heat conditions they have been subjected to, this bringing up the questions of fluidity, melting and casting temperatures. In general, we say that the hotter the melted iron the greater its fluidity (and incidentally the shrinkage); that is to say, if an iron which melts at 2200° F. is heated up to 2400° before pouring, it will be more fluid than if only 2250° , and consequently be likely to properly fill up very thin sections. Our common experience is that the higher the carbon, silicon, manganese, and especially phosphorus, the greater the fluidity

of the iron. Sulphur acts the other way. Moreover, dissolved oxygen, which means burnt iron, takes all the life out of the melt, makes it stick in the ladle, and gives rise to misruns, dirty and spongy castings.

It is an open question still why white irons chill so rapidly, making it necessary to lose no time in pouring after tapping, while the gray irons can be transported for miles from blast furnace to converter, or held in ladles pending the ordinary delays incidental to daily work. True, the melting point of white iron is lower than the gray, but there should be about the same rate of cooling in both, unless—and this is quite likely—there are chemical reasons to hasten the congealing of the white varieties.

The one point which must not be forgotten here is this. After an iron is brought up to its melting point, it takes further heating to melt it, a situation parallel to making water from ice. Thus a white iron must be raised to about 2,100° F., and then requires one-tenth of the number of heat units consumed in doing this, in addition, to melt it. With the gray irons, which melt at only 150° F. higher, there are more heat units made latent, the total amount for them being about 10% higher. Aside from chemical conditions, and a possibility that the freezing point of each class of iron varies somewhat from the melting temperature (matters on which we have no information as yet), this circumstance may help to account for the remarkable length of time a gray iron may be kept fluid; for all this latent heat must be given out before it sets.

As to the melting point of cast iron, it was the good fortune of the writer to contribute a series of observations, on a wide range, of white and gray irons only last month, thus corroborating, by actual trial, the daily experience of observant foundrymen. The set of 57 pig and cast irons, with but few exceptions, had no abnormally large variations from ordinary standards, but the range of silicons, from .14 up to 3.29%, with their corresponding variations in combined and graphitic

carbons, were admirably adapted to bring out the influence of the former to lower the melting point. The two extremes only are given herewith: a white iron which melted at $1,990^{\circ}$ F., having 4.20% combined carbon, and a gray one going at $2,280^{\circ}$ F., or 290° higher, contained only .13, the balance of the 3.56% total carbon being graphite. To properly determine the influence of phosphorus, manganese and sulphur on the melting point, it would be well to take an iron which remains perfectly white at all casting temperatures, and add to it different proportions of these elements while it is in a melted state, casting each resulting mixture at once. In this way, all the carbon remaining combined, a good comparison would be obtainable.

In connection with the molecular structure of cast iron, its specific gravity is of some interest. The whiter the iron, the higher this will be, for not only does the space occupied by graphite, in the gray irons, decrease their density, but the very fact that they are gray, when cast under normal conditions, indicates that they may contain up to 3.25% of silicon. Thus the specific gravity of white iron is given as 7.6, and that of gray at 7.0. This difference has its influence in practice, for it is customary and convenient to simply weigh the pine pattern and multiply by 16 to get the weight of iron required to pour the casting. While this does very well for ordinary gray iron casting, the white varieties require a higher factor.

In a number of determinations made by the writer on the specific gravity of cast irons, the upper limit given above was extended a little, results as high as 7.8 being found where a white iron had been cast into chills. Gray irons which were chilled had the specific gravities raised 0.3 above their normal figure, thus showing the difference in density brought about by a change in carbons, from graphite to combined.

The purpose for which a casting is to be used, naturally has, or should have, a deciding influence upon the kind of irons

selected for making it. The days when anything went have passed, and the result has been a very discriminating specialization of the work. In a jobbing foundry, this may be taken care of, to some extent, by suitably mixing the charges in the cupela, but in general, we find the best results obtained in shops arranged with their special ends kept constantly in view.

Here are a few varieties which show the flexibility of the general appellation, cast iron: heavy and light machinery castings, stove plate, light and heavy for air, ammonia, or steam; brake shoes; car wheels, which have gray centers and chilled rims; similarly chilled rolls; sand rolls, that is, rolls not chilled on their surface; gun metal, which is made in the reverberatory furnace, and embraces a variety of sub-divisions; dynamo frame castings, in which magnetic properties are essential; ornamental castings, from radiators to imitation suits of armor, plaque, and even the exact reproduction of insects used as a pattern; pipe fittings; novelty work; hardware and agricultural machinery castings; pipe; plows, with their chilled points; ingot molds; sash weights, the scavengers of the junk piles, etc.

All these materials are produced for the purpose indicated in the classification just outlined, by a proper adjustment of the silicon, phosphorus, manganese and sulphur contents within the range indicated in the early part of this paper, and coupled with physical manipulations, characteristic to foundry practice. Fortunately, where extreme ornamentation is desired, strength is no special object, and vice versa. There are, however, sometimes requirements specified which puzzle the foundryman not a little, for instance, where great strength is to be combined with ease in machining, amounting to practically an iron which is at the same time hard and soft. Naturally, in this instance, a sufficient amount of steel scrap is added to give strength by the reduction of the total carbon, and the silicon is kept up high enough to throw as much of the carbon present in the graphitic state as possible.

The strength of the iron is dependent upon its composition and the physical treatment received until a finished casting. Even afterward, the service conditions have a deteriorating effect, but little estimated, in fact, a value almost unknown as yet. Cast iron having for practical purposes no elastic limit, the actual breaking tests are better calculated to represent service conditions than is the case for all the other forms of iron. The strength of cast iron, as shown by physical tests, ranges between very wide limits. Not only will the different kinds of cast iron run far apart, but actually the same iron when cast into various sections, shows a distressing lack of homogeneity, which makes comparisons the merest guesswork. What methods of testing to adopt, what test pieces to use, etc., is now occupying the attention of several national bodies of men interested in industrial progress, both here and abroad, and the outcome, it is hoped, will be of much benefit to the manufacturers and consumers of iron castings.

The tensile test is one very difficult to apply properly, but gives sufficiently high values to allow a differentiation, having a given size and shape of bar cast under as nearly the same conditions as possible. The tensile strength of cast iron may run from 14,000 up to 35,000 pounds per square inch, the former being found in soft, but bulky castings, and the latter in the highest grade of gun metal, strengthened with the addition of steel scrap. Here we see the effect of lowering the carbon in the casting, the strength, as a consequence, going up. High silicon lowers the strength; phosphorus, when not over 0.5%, which is the safe foundry limit, rather stiffens the iron, makes it pull stronger, but leaves it brittle. Ordinarily, castings should run between 17,000 and 20,000 pounds per square inch tensile strength.

The modulus of elasticity of cast iron varies from 10,000,000 to 30,000,000, showing the utter lack of value of tests made on cast iron, unless all the conditions existing at the time are taken into consideration, and preferably all the

outside influences affecting the results removed as much as possible. Again, a set of bars of the same cross section, but of regularly increasing length, when tested showed a regularly decreasing tensile strength, the last being actually one-half as strong as the first. Results of this kind shake one's faith in all tests on cast iron, but this very circumstance makes it all the more important to dive deeper into these mysteries and get more light and those rewards, always coming (usually to the other man, however), from patient investigation and study.

The transverse test of cast iron is the easiest to carry out, and with the same cross section, same distance between supports and the identical method of testing, the records are in some measure comparable. Yet it is idle to wade through elaborate tables giving the modulus of rupture of cast iron calculated to the square inch, when we know that the same iron, in bars of the same section, when tested with varying distances, between supports, gives hopelessly discordant values when the regulation formulæ are applied. No wonder that the modulus of rupture per square inch, for cast iron thus calculated, varies from 10,000 to 65,000 pounds. In making transverse tests, the load applied to produce rupture, as well as the deflection, should be noted. Here, also, we have the effect of a moderate amount of phosphorus, showing itself in an increased strength and amount of deflection, but it will be noted that this is the case only with a very gradually-applied and slowly-increasing load, for the slightest shock means an instant break.

The crushing strength of cast iron is, so to say, its strongest point. It varies from 40,000 to 200,000 pounds per square inch. This test is seldom made, for if the iron is sufficiently strong to come up to all the other requirements, that of resistance to crushing is almost superfluous. Nevertheless, for certain classes of work, such as rolls and hammer dies, much could be learned in this way, especially when combined with heat conditions.

Impact tests on cast iron are almost unknown, but could be made with considerable profit, even though objections have been made on the ground that cast iron is never exposed to shock while in service. Once efficient machinery for this method of testing is provided, we shall hear more of it. We now have some vague ideas of the resistance of cast iron to shock from resilience calculations made of bending tests, but these results are empirical and need further extension and study.

A test for the hardness of cast iron would be a desirable addition to our list, and several ingenious methods have been brought out for this purpose. They will fail to be adopted generally, for we again strike the lack of homogeneity in cast iron which will leave the skin harder than the interior, and the cooler portion of the iron, while casting, softer than the hotter immediately at the gate. The methods of testing hardness, commercially, will, therefore, remain of local application, each shop requiring such a test getting up its own modification. Careful regulation of the mixtures and casting temperatures should go a great way to make this style of test only desirable in special cases.

There are other tests, such as punching and shearing, for fluidity, contraction, chill, behavior under heat, etc. This much can be said, that the testing of cast iron is in so crude a state as yet that formulating elaborate specifications to cover anything but the most general points is often a positive injustice to the founder, and moreover, a retardation of progress toward an international agreement on standard methods of testing.

The writer has not dwelt much upon the effects of the various constituents of cast iron when present in large quantities, deeming this subject rather over-written of late. He begs the indulgence of his audience for any shortcomings in this hasty sketch of a widely diversified but highly interesting branch of the vast iron industry.

DISCUSSION.

Mr. W. A. Bole—Is there any virtue, apart from the cheapening of cost in the use of scrap iron in a cupola, scrap being said by some foundrymen to assist in making the castings solid. I would also like to have Dr. Moldenke tell us something about the effect of annealing cast iron for softening it.

Dr. Moldenke—As regards scrap iron, a certain amount of scrap is found necessary to get dense enough results, say one-half pig and one-half scrap. If we use too little scrap, the castings will be too open in their crystalline structure. If we use too much scrap, we run into other difficulties, such as excessive shrinkage, internal strains, undue hardness, and the like.

The addition of ferro-silicon enables us to use as high as 90% scrap: 40% to 60% will, however, be found better adapted for routine work. What the exact molecular effect is, is not known. I should not advise 90% scrap with 10% ferro-silicon. I have seen castings with round globules of ferro-silicon in them, showing the difficulty of proper mixing. As regards annealing, what kind of annealing do you refer to?

Mr. W. A. Bole—I refer to ordinary light foundry work. What do you think about the annealing of small castings and about the annealing of large ones?

Dr. Moldenke—If we take gray iron castings and anneal them too long, it makes them rotten. The best thing to do is to put them in a furnace for, say one or two days, at about 1150 degrees to 1200 degrees. This relieves the casting strains. They should be heated quickly to redness and cooled very slowly. The thinner the casting, the shorter the period of heating, as the oxygen goes through and burns them. I have seen gray castings annealed too long and broken up, which showed a banded structure similar to a many-colored ribbon. As regards malleable iron, I regret that I cannot say as much as I should like to about it, for business reasons.

MR. G. E. FLANNIGAN—Does melted cast iron expand at the moment of solidifying?

DR. MOLDENKE—Yes; one can see that from the fine lines of good castings, and would also expect it from the difference between the specific gravities of white and gray iron, the separation of graphite meaning an expansion. To show that iron fills the fixed lines, there may be quoted the example of a grasshopper molded in clay, and then baked until the insect was reduced to ashes; after shaking these out and casting with a fluid hot high phosphorus iron, a perfect model of the grasshopper was obtained. Expanding in settling, on the part of fluid iron, is an undoubted fact, but what happens afterwards is still open to investigation, for it is quite possible that changes in volume occur comparable with the molecular re-arrangement in steel due to recalcence. I have, therefore, suggested a new way of measuring the change taking place, and that is by casting a bar with little arms in it, these revolving mirrors and reflecting beams of light on bromide paper. White iron which has a shrinkage of one-fourth of an inch per foot should give excellent data.

MR. W. E. GARRIGUES—Do you hold that gases in iron are due in part to absorbed oxygen?

DR. MOLDENKE—I won't say exactly. There seem to be two forms of this trouble, one in which the gases are intermolecular and come out at the moment of solidification; and the other a dissolved oxide. When oxidized iron is tapped, it runs fluid as water, but soon chills. If we attempt to pour it into moulds, failure will result. The philosophy of the gas truth seems to be an absorption of a small quantity at first, which if checked by using the iron, may be taken care of by proper manipulation. If the iron is subjected to further oxidation, however, it is no longer a question of intermolecular gases, but actual burning. This means dissolved oxide of iron, and disastrous results. When iron is low in silicon, there will be a noted tendency toward gassing. If iron sets

too quickly, as the gas cannot escape, we get blow holes. We should, therefore, run heats as quickly as possible. Whether it is oxygen or nitrogen, or hydrogen that is in the mold, I do not know, but the fact seems potent that a temperature of 2300 degrees F. is not high enough to make all the oxygen combine with carbon and pass off.

MR. GARRIGUES—It is difficult to see how carbon can affect the oxygen, and yet not combine with it.

DR. MOLDENKE—The fact is shown because in castings we have blow holes.

MR. BOLE—I have watched a ladle full of molten iron in which bubbles rise and burst on top. Is this due to steam from the lining or some kind of internal combustion?

DR. MOLDENKE—It is very likely the moisture from the lining of the ladle.

MR. PHILLIPS—I have a good deal to do with low silicon iron in about 33 casts. Have seen it as low as .035% silicon. In the casts it ran .1 to .6 of a per cent. silicon. I have observed a gasing which confirms what Mr. Moldenke has stated. When we began to cast in chills, we got holes as large as hen's eggs, and in breaking up the castings, they sometimes exploded. Percy says he noted cases where the gas burned when the pig iron was broken. We only got these holes when the iron ran low in silicon. When silicon was 7%, we got no holes (in a sister furnace). The darkies who broke up the pigs say they exploded when struck by the hammer.

MR. CAMP—I would like to ask if the presence or absence of gas is not due to temperature only? Gas occluded in iron seems to be entirely CO. It is well known gas in steel is CO; it escapes and burns with its characteristic flame. I noticed this gas in iron from a Duquesne furnace casting chill iron. The fracture of the iron showed small holes, and these were clean and bright, showing that it could not be oxygen. In the use of scrap, we have used 20% steel scrap in our cupolas, taking samples from cupolas every six hours for an entire

week. Combustion analysis of these samples showed the carbon to be normal, showing that scrap did not lower the carbon, or rather that the steel was carbonized and changed into pig iron.

DR. MOLDENKE—Your result depends upon the length of time the steel is in contact with the incandescent fluid.

MR. CAMP—Cupolas in steel mills run faster than foundry cupolas ; 200 to 250 tons per day is usual.

DR. MOLDENKE—This is far beyond the ordinary run of work, and the results would hardly be comparable.

MR. CAMP—I do not believe that oxygen can exist in liquid cast iron under normal conditions of temperature. There are too many elements present ready to seize the oxygen. The iron itself, carbon, silicon, manganese, all have powerful affinities, increasing with temperature, and under normal conditions of temperature, of good cupola practice, the iron will clear itself of oxygen and resulting oxides.

DR. MOLDENKE—I notice you say that the blow-holes you observed had a bright surface. My experience differs. All mine were coated with black oxide of iron, and as I am using low silicon and you high silicon iron, very likely the difference comes in here. You very likely run your cupola at a higher temperature, have more fuel for the steel to pass through, and hence get higher carbon. The maximum carbon thus obtained by direct contact of melted iron with incandescent fluid is about 400%.

MR. WILSON—In the annealing of cast iron I have made many experiments. Cast iron should not be annealed always. For successful carrying out of some large contracts, the habit of spokes of wheels cracking was avoided by putting them in a furnace and annealing. We produced a thousand-chained sprocket wheel in this way, which formerly gave trouble from the spokes cracking and lost 25 to 50%. After annealing them, we had no cracks, (the temperature was 450 degrees), they were taken right from the moulds and not allowed to cool

off. I would like to know something about cast iron for electrical purposes.

MR. BOLE—I would like to point out the heterogeneous nature of pig iron. Is there not a great deal of ambiguity in analysis? Can a foundryman be certain by having pig iron analyzed whether it is good or not?

DR. MOLDENKE—I am sure that he can, for the variation you mentioned can be overcome. When a car load comes in, I have it spread out on the ground in a row, then have the next car spread on top of that and so on. By drawing from end, a good arrangement or mode on taking ore analysis of 5,000 tons in this way, the charges would not vary 0.2% of silicon one way or the other. One is very apt to be misled by buying fracture. Two kinds of iron can show the same fracture, if cast at suitable temperature.

MR. BOLE—Then the best way to do is to buy five or six brands from five or six makers and mix them.

DR. MOLDENKE—Yes; though by using one brand carefully checked up, good results are obtained. I have taken samples of iron from the same car load and got widely ranging silicon results. But, by piling up in the way I stated, the silicon will run very uniformly.

The meeting adjourned at 10:15.

REGINALD A. FESSENDEN,

Secretary.

MEETING OF THE CHEMICAL SECTION.

The regular monthly meeting of the Chemical Section was held November 17th, 1898, in the rooms of the Society.

Chairman J. O. Handy presided.

Attendance, 12.

The minutes of the last regular meeting were read and approved.

On motion of Mr. Camp, the Section voted to have the

Chairman appoint a Nomination Committee of three to report at the December meeting on nominations for officers of the ensuing year.

The following committee was appointed: J. M. Camp, W. H. Coster, F. C. Phillips.

Mr. W. E. Garrigues then addressed the Section on the Analysis of Alloys.

After a brief discussion of the paper, the Section adjourned at 10 P. M.

A. G. McKenna,
Secretary C. S.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The one hundred and eighty-ninth regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the Society's House, 410 Penn Avenue, Pittsburgh, Pa., Tuesday evening, December 20, 1898, the President, Mr. Geo. S. Davison, being in the chair. The meeting was called to order at 8:20 P. M., 86 members and visitors being present. The minutes of the preceding meeting were read and approved.

For the Board of Direction, the following applicants were reported as passed:

J. B. BRENEMAN,	- - -	Analyst, with the Duquesne Chemical Laboratory, 336 Fourth Ave., Pittsburgh, Pa.
WM. CLIFFORD,	- - -	Mining Engineer, 232 Fifth Avenue, Pittsburgh, Pa.
JAMES GAYLEY,		with Carnegie Steel Co., Carnegie Building, Pittsburgh, Pa.
HARRY W. GIBSON,	- - -	General Contractor, No. 27 Fifth Avenue, McKeesport, Pa.
THOMAS G. HAMILTON,	- - -	Street Railway Construction Engineer, 5912 Margharetta Street, Pittsburgh, Pa.
C. K. LAWRENCE,	- - -	M. W. Union Railroad, 1006 Carnegie Building, Pittsburgh, Pa.
JOS. R. PATTON,	- - -	General Contractor, 4737 Maripoe Avenue, Pittsburgh, Pa.
WM. B. PHILLIPS,	- - -	Editor of the <i>American Manufacturer</i> , 59 Ninth Street, Pittsburgh, Pa.
JAMES LEE RANKIN, JR.,	- - -	Draughtsman, Carnegie Steel Co., 334 South Highland Ave., Pittsburgh, Pa.

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KENNETH O. P. REINHOLDT, Ass't to Chief Engineer,
 P. B. & L. E. Railroad,
 1309 Carnegie Building

R. R. RICHARDSON, - - Supt. Transportation,
 Duquesne Steel Works
 and Blast Furnaces,
 Carnegie Steel Co.,
 Duquesne, Pa.

RALPH V. SAGE, - - - Engineer,
 at Keystone Bridge Works
 of Carnegie Steel Co.,
 126 Graham Street,
 Pittsburgh, Pa.

WILLIS WHITED, - - - Engineer,
 with Keystone Bridge Works
 of Carnegie Steel Co.,
 286 Main Street,
 Pittsburgh, Pa.

The following were balloted for and duly elected to membership :

HARRY P. DAVIS, - Electrical Engineer,
 with Westinghouse Electric & Mfg. Co.

GEO. W. NOCK, - - - Engineer, as Engineer of Works,
 Westinghouse Electric & Mfg. Co.

SAMUEL PETERS, - - Metallurgical Engineer,
 with Pittsburgh Reduction Co.

LAWRENCE C. PHIPPS, - Second Vice-President and Treasurer,
 of the Carnegie Steel Co., Ltd.

For the Nominating Committee, Mr. Ralph Crooker, Jr.,
 Chairman, reported as follows :

For President, (to serve one year),

H. J. LEWIS.

For Vice-President, (to serve two years),

H. W. FISHER.

For Directors, (to serve two years),

P. T. BERG and F. C. PHILLIPS.

For Secretary, (to serve one year),

REGINALD A. FESSENDEN.

For Treasurer, (to serve one year),

A. E. FROST.

For the Reception Committee, Mr. Davison stated that
 any wishing to subscribe to the expenses of the smoker, would
 please send their subscriptions to the Secretary.

For the Library Committee, Mr. Albree stated that the books were in place and numbered, and that all that remained to do, was the completion of a card catalogue.

It was voted that the Chair appoint a committee to audit the books of the Society. The Chair appointed the following members :

W. G. WILKINS, *Chairman*,
FRANS ENGSTROM,
CHARLES FITZGERALD.

Mr. Daniel Ashworth then made some remarks on H. R. Bill 10,403, for the reorganization of the Naval Personnel, and offered the following resolution, which was voted :

“Be it resolved by the Engineers’ Society of Western Pennsylvania :

“That the Bill now pending before the Congress of the United States, known as the Naval Personnel Bill, meets with the hearty concurrence of this Society. Also, that our Secretary be instructed to communicate with the Hon. John Dalzell, requesting his support and vote for this measure. Also, that the same request be made upon Hon. W. H. Graham, and that the Society request such members having acquaintances with other representatives in Congress, to vote for and support same.”

It was then voted that a committee of three be appointed to wait upon Mr. Dalzell, on his coming to Pittsburgh, to express to him personally the wishes of the Society. The following committee was appointed : Messrs. Daniel Ashworth, Ralph Crooker, Jr., and Reginald A. Fessenden.

The question of appointing a committee to take up the matter of the smoke nuisance in Pittsburgh was then raised, but was laid over.

The paper of the evening, entitled “Design and Construction of the Twentieth Street Power Station of the Consolidated Traction Company,” was then read by Mr. G. F. Greenwood.

DESIGN AND CONSTRUCTION OF THE 20th STREET POWER STATION OF THE CONSOLIDATED TRACTION COMPANY, PITTSBURG, PA.

BY G. F. GREENWOOD,

Chief Engineer and General Manager, Consolidated Traction Co.

When the various Cable and Electric lines in the City of Pittsburg were consolidated, the new Company found itself in possession of seven Power Houses, four of these, namely:—Washington Street, Oakland, Wylie Avenue and 34th Street, were Cable Power Houses of the usual type; the other three, 47th Street, Ben Venue and Allegheny Traction, were Electric Power Houses.

Before, and during the reconstruction of the system, these Electric Power Houses were of course kept in operation, but there arose the problem as to what arrangements must be made for supplying power to the much larger system when completed. An examination of the following list and map will show the situation as it stood :

POWER DATA OF ORIGINAL STATIONS.

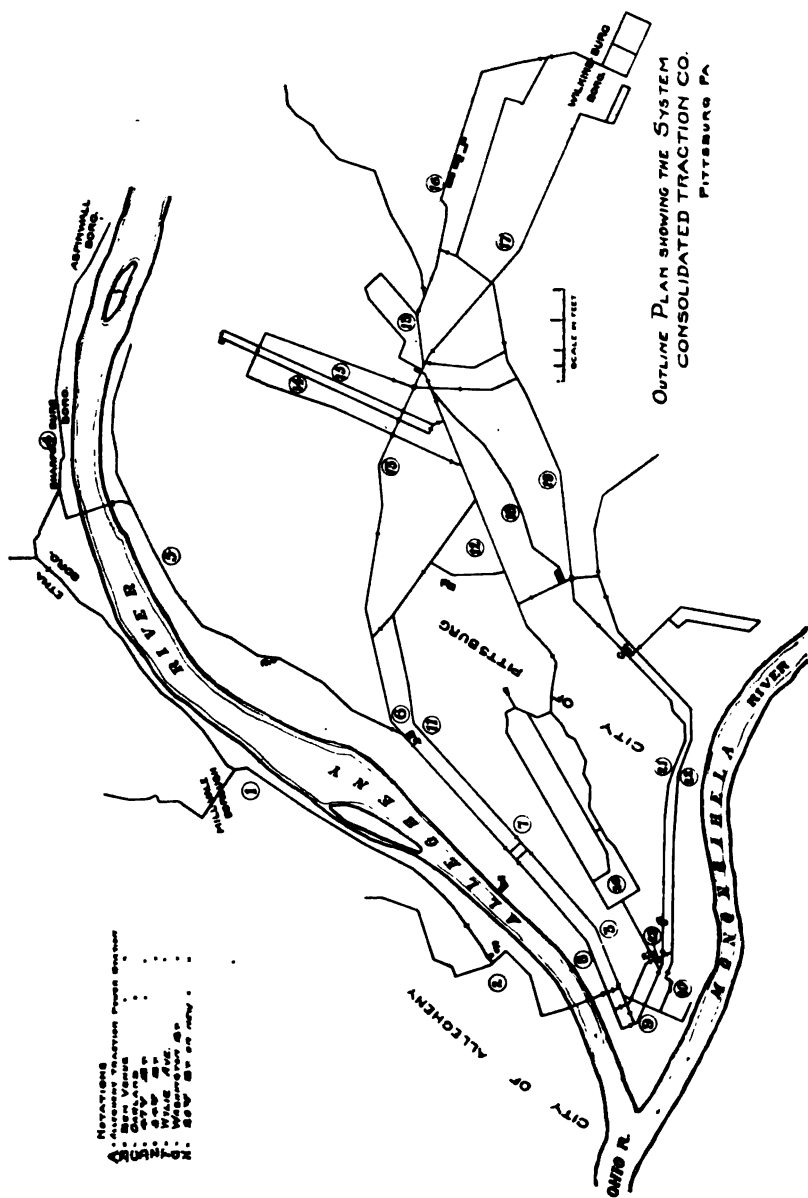
Letter	Name.	Boiler.		Engines		Total IHP.	Machine Driven.	Cost Coal.
		HP.	Type.	No.	Size.	Type.		
A	Allegheny Traction.	750	W. T.	2	14x28x20	VCCC	500	2-200 KWGen.
				1	21x42x30	"	750	1-500 KWGen.
B	Ben Venue.	1200	T. T.	2	32x60	H	1200	2-500 KWGen.
				1	2-22x42	H	450	1-375 KWGen.
				1	2-24x48	H	600	1-500 KWGen.
C	Oakland.	800	R. T.	2	28x60	H	1000	1-800 KWGen.
D	47th St.	300	R. T.	3	11x19x24	H/TCC	600	3-100 KWGen.
E	34th St.	800	R. T.	3	28x60	H	1500	Cable Machine
F	Wylie Ave.	100	R. T.	3	2-28x60	H	1500	" "
G	Washingt'n Street.	200	R. T.	1	22x48	H	250	" "

R. T.—Return Tubular.

V. C. C. C.—Vertical Cross Compound Condensing.

W. T.—Water Tube.

H. T. C. C.—Horizontal Tandem Compound Condensing.



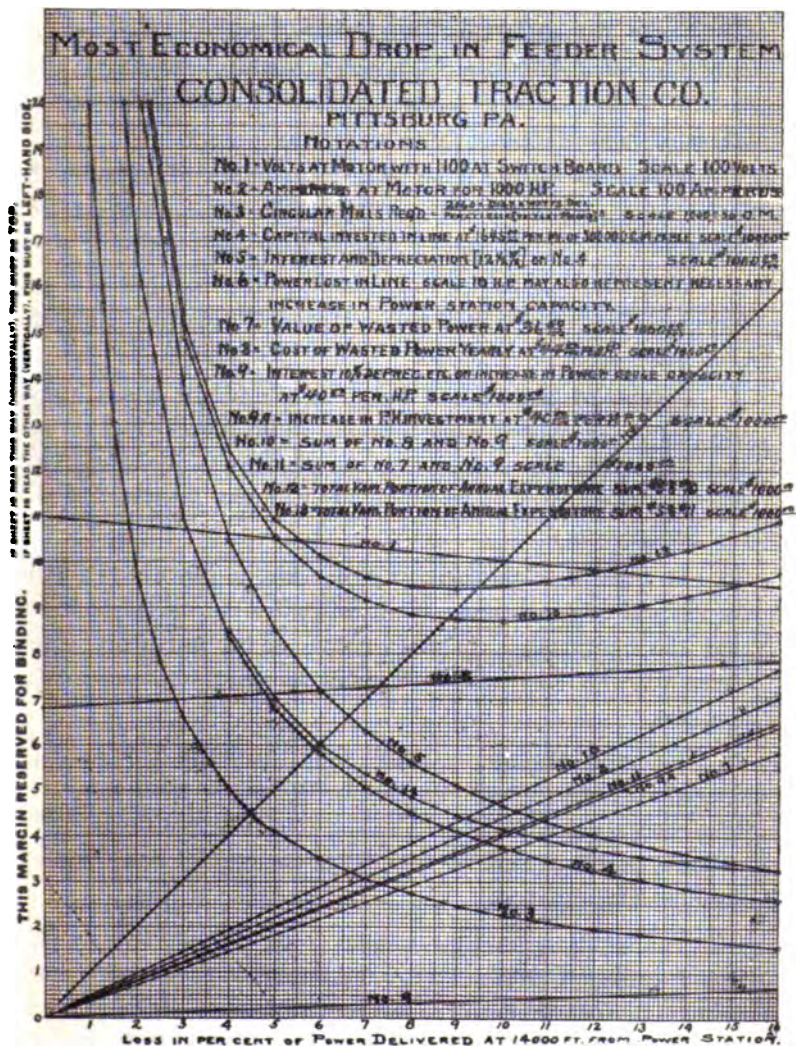
It will be seen that none of these plants were well situated with regard to coal and water supply, the most important factors in the location of a large Power House.

The Cable Power Houses were necessarily located on the streets along which the cables were operated, and therefore little regard was paid to coal and water supply. These plants stood on valuable ground, the cost of hauling coal by wagon was large, and lack of water rendered the use of Condensing Engines impractical.

The Electric Power Houses were somewhat better off in regard to coal supply, but 47th Street and Allegheny Traction were too far from centre of system, while Ben Venue had no suitable water supply, and only one source of coal supply. It became evident, therefore, that one or more new power stations were demanded in localities not too far removed from centre of system, and where coal and water were easily and surely obtainable.

In deciding between one large plant and two or more smaller ones, Pittsburg's marked geographical peculiarities largely influenced the result. The street railways converged in the crowded business portion down town, and again at East Liberty, after traversing a district of heavy grades.

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., U. S. A.



This brings the centre of the system in the midst of the hills, as shown on the map, at a considerable distance from available coal and water supply, hence it was impractical to put Power House in this part of the system. Railroads are compelled to follow the Monongahela and Allegheny valleys, so that both coal and water are readily obtainable along the banks of these rivers.

A location on the Allegheny river offers advantages of far better water, with equally good coal facilities, nearest to the centre of the system, and of less difficulty in obtaining land.

With so little choice in location, the advantages of a single Power House, rather than two or three in different parts of the City are clear.

Danger of fire and of accident to a single plant may be eliminated by proper construction, while much of the initial cost and operating expense of the plant is independent of the size, and therefore, as great for each of the smaller plants as for the large one.

To illustrate, the economy of a single power station over the several original ones—your attention is called to the fact that the operating expenses of five of the old plants as compared with the new one—are about two and one-quarter times as great.

The new station is larger than the combined capacity of the old stations considered, yet runs for less than one-half the daily operating expense. The value of the real estate of the separate plants is sufficient to cover the cost of construction of the new Station.

The location finally obtained is at Twentieth Street, between Railroad Street and the Allegheny river; the property being 177 feet deep, and 360 feet to harbor line; the length of the building is limited to 265 feet by the 30 foot right of way of the P. J. R. R. crossing the property at the river end; thus coal may be secured from either the B. & O. system, the

Penna. Lines, or ultimately from the river, while an unlimited supply of fairly good water is close at hand.

The depth of the property is not as great as was desired, and in order to allow room for future extension, close attention was paid to concentrating the plant within as small floor space as possible.

The total power required was deduced from power data from the P. A. & M. Lines in Allegheny, and from the results of the testing car, and checked later by observations on the Fifth Avenue Line. This with the proposed schedule, gave the capacity of the Station to be about 6,000 K. W.

This was divided among six machines, with foundations, etc., for two more, without making additions to the building. By economizing space, it was arranged so that the plant may then be doubled in size with very little trouble. Until this becomes necessary a part of this space is used for the storage of coal.

The plant will use about 100 tons of coal per day, thus requiring a large storage capacity in case of strikes.

In the selection of boilers, Return Tubular Boilers were out of the question, owing to the large amount of space they occupied. Sectional Water Tube Boilers were chosen, rather than Internally Fired Boilers of the marine type, because of their being cheaper, equally efficient, safer, and better adapted to the exacting requirements of street railway work.

Each battery of two boilers is provided with a separate iron stack, this being cheaper and more economical of space than a system of flues connecting with a single large stack.

A single stack would have to be 15 feet internal diameter and would occupy as much room as a battery of boilers, aside from the space taken up by the flues, and would cost very much more. Under partial load there would be a loss of efficiency due to the large amount of air necessary to be heated in order to obtain the requisite draught.

Brass feed piping was selected, inasmuch as the freedom

from corrosion and repairs overbalanced the greater first cost.

Cast steel steam piping was selected, because of its greater safety and durability.

Duplicate piping was not provided, as it was considered that the money could be better spent on the Main Line than on a duplicate line not used often enough to be sure that it was in good order.

In the design of the engines, Horizontal Engines were chosen, because (contrary to the usual statements) they can be put in even less floor space than Vertical Engines, are more readily accessible for attendance and repairs, and are less expensive. Low speed compound Condensing Engines were chosen because they were found, on calculation, to be the most economical under the conditions present.

Although no reference to published papers was made at the time of the design, it may be interesting to compare the result with Emery's table in his paper on the cost of Steam Power (Transactions A. I. E. E. May, 1893). By taking coal at \$1.00 per ton and the engine consumption as 18 lbs. and 15 lbs. of water per horse power, his figures for railway work 20 hours per day—365 days in the year, where machinery 50% in excess of average must be installed, become as follows:

	On 18 lb.	On 15 lb.
Simple Low Speed Condensing.....	\$37 64	\$36 15
Compound High Speed Condensing.....	37 51	36 05
Compound Low " ".....	36 54	35 20
Triple High " ".....	36 44	35 20
Triple Low " ".....	37 10	35 91
Triple Low " ".....	37 74	36 62

Greater ease of regulation, less floor space occupied, and less initial cost, decided in favor of low speed compound Condensing Engines. These figures agree very well also with the estimate of $\frac{5}{100}$ th of one cent for the cost per horse power hour delivered from the Station, which was taken as the basis of the calculation of the feeder system.

A direct connected air pump was chosen for the following reasons: The river level varies so much that any style of

pump would have to be designed to do more than is ordinarily required of it, hence the pump will rarely be running at full load, and will therefore be less economical than in the case of more uniform water supply; the effect on the economy, however, is less in case of direct connected air pump where it practically forms part of the friction load of a large compound condensing engine, than in the case of either a single separate pump or a number of smaller pumps designed for economy.

Separately driven pumps are more expensive (if equal workmanship is obtained) because the cost of steam cylinders and valve gearing is added to that of the pump itself; starting with a direct connected air pump is very much easier and practically no attendance during operation is required.

The main disadvantage is that the engine must be run non-condensing in case of break down of its own pump.

In the design of the foundations, it was necessary to avoid the possibility of a flood stopping the plant, hence the engine room floor level was fixed 1 foot above the highest recorded level of the river (a stage of 33 feet 8 inches in 1884), normal pool level being stage of 6 feet. On the other hand, the intake pipe must at all times be completely covered with water, thus requiring the top of the pipe to be below stage minus 1; the pipe had to be kept below this level underneath the engines, to keep the vacuum from being lost in times of low water, hence there was required an excavation over 300 feet in length and over 40 feet deep from the surface, or 13 feet below normal river level. This pipe was surrounded with concrete to make it permanent, and to secure good foundation for the engines above.

Concrete was chosen because of the ease of handling it in difficult places, such as under caving banks without removing bracing in water, etc.

For the outside walls as much lumber and labor would have been necessary for bracing walls while the brick or

masonry was being put in, as would be required for the forms for concrete walls.

In the case of the engine and boiler foundations, concrete can be deposited more cheaply because of forms and machine mixers included, than either brick or masonry, and makes better foundation. This subject will be referred to again.

Coming now to the electrical side of the plant, in the choice of a system, one could choose between the 500 volt direct current system, in almost universal use throughout the country, and the Polyphase alternating current transmission at high voltages to sub-stations where transformers and rotary converters would deliver the 500 volt direct current to the lines.

The latter system would involve high voltages on iron poles in crowded city streets, and the sub-stations would contain rather costly machinery, and require constant attendance. In addition, each sub-station would have to be designed to take care of the average maximum load, which might come on its feeders during the very widely fluctuating demands of a street railway system, while nearly all of the time this machinery would be running under-loaded. Hence, from an engineering standpoint this system is hardly advisable, while from a purely commercial point of view, one is hardly willing to be responsible for the expenditure of a large sum of money on what may properly at the time have been considered an experiment. A higher voltage direct current system was not advisable, first, because special generators, motors, etc., would have to be installed; this change from standard practice meaning an increased expense which would be counterbalanced in saving in copper, and second, because of increased danger to life and property from wires in crowded city streets.

The standard 500 volt system was therefore continued in use; certain advantages can be obtained, however, by what may be called the "three-wire system."

The switchboard is so arranged that any dynamo may be

run, alone or in parallel with others, with either its positive terminal to one bus bar, and its negative to ground, or with positive to ground and negative to another bus bar, while any feeder of the system may be connected to either bus bar.

Suppose, then, that the down-town districts are connected to the positive bus bar, and suburbs to the negative; the feeding load on the two sides is equal—the current going down town by means of the positive feeders will, after passing the motors, flow to the suburbs through the ground, distributing itself over the several lines of rail, and will pass through the motors in the suburbs, and thence to station by means of the negative feeders, no current whatever returning through the ground to the station.

If, as is always the case, the loads are unequal on the two sides, the difference in current only will return to the station by means of the ground or neutral. This corresponds therefore to a 1100 volt system—with both positive and negative overhead feeders rather than 550 volt system with positive feeders and negative ground return. The advantages are the somewhat smaller drop and great freedom from electrolysis due to the fact that large current does not return to the station through the ground, but distributes itself over a large area of the city, with the resultant decrease in the necessary investment in ground wire.

The disadvantages are complication of the Switchboard, and the necessity of having special 1100 volt circuit breakers on the lines, since failure of one of these breakers would produce short circuit. By merely connecting all the feeders to one bus bar, the system becomes the usual one, but if intended to work along under such a condition, larger ground returns must be provided, and thereby the saving in investment annulled.

In the design of the feeder system, two extremes are to be avoided—either having too small overhead wires, in which case the cost of power alone due to resistance of feeder,

becomes excessive, or having too large overhead wires, in which case the interest and depreciation on the investment involved, becomes excessive.

It is evident, that there is a happy medium which represents the most economical condition of affairs. The calculations gone through are shown graphically in the following figure, and lead to a result which, curiously enough, for the cost of power and the average distance in the present case, coincides with the value usually assumed off-hand in such work.

Another feature which may be mentioned here, is the use of the storage batteries as regulators at different points in the system. Three of these batteries are already in use; they are connected directly on to the line, and during the greater part of the day act as automatic regulators, at times discharging and helping the power house when the load rises momentarily, and charging again when the load falls below the average, thus keeping the potential and the load on the power station more constant, and avoiding the necessity of having more engines running at less than full load, in order to take care of the greater momentary heavy load. During the busiest hours, the battery discharges continuously; charging continuously between midnight and 5 A. M., to compensate for this drain.

CONSTRUCTION OF PLANT.

Excavation was begun September 1st, 1897, the material being shoveled directly into cars on the siding leading on to the property. As the excavation deepened, and the grade became so heavy that this method became impractical, two machines were used. At the river end, where there remained a large quantity of loose filling, a bucket conveyor, driven by street car motor was erected, and the material brought by scoops to bottom of conveyor and loaded into cars.

In this way, as much as 25 car loads of dirt could be loaded during each shift of ten hours, but the usual number

was considerably less than this, owing to scarcity of cars and other delays.

The other machine was used in excavating the deep trench for the 60" intake pipe, and was a Brown Traveling Hoist, formerly used in pulling out cable track—the boom having been lengthened from 14 to 40 feet, in order to give greater radius of action. This ran along a track in the shallow part of the excavation, and was able to lift buckets holding not quite a cubic yard from a ditch 40 feet below surface, and dump them directly into the ears 70 feet to one side; both these machines proved very valuable aids in the work.

Total excavation amounted to roughly 35,000 cubic feet.

This work and the earlier part of the concreting which was carried on at the same time were prosecuted in the face of serious difficulties—heavy rains which caused the loose banks to fall in, in spite of strong bracing, and winter weather, and frequent floods, were the principal things with which to contend.

The deep ditch previously mentioned was the cause of a great deal of delay. The lowest part of the excavation was 13 or 14 feet below normal river level, thus requiring continuous pumping of large quantity of water which flowed in rapidly from the stratum of gravel, apparently not intimately connected with the river. This water, compared to river water, was noticeably warmer, clearer, more acid, and flowed in most strongly at the end farthest from the river. In addition, our pumping lowered the water several feet in wells several hundred feet distant, all of which tends to show the existence of a stratum of water purely gravel underneath the bed of the river.

Two 100 H. P. Return Tubular Boilers were set up temporarily, three Centrifugal Pumps; two Pulsometers, the Engines for the Concrete Mixer and other apparatus.

In the concreting, hand-mixing was out of the question, and a machine mixer was therefore erected. As this contained some novel features, it will be described in detail.

The Mixer structure was a strong wooden frame work,

about 20x16 feet, and 32 feet high; on the ground floor was the engine and countershaft; on the second floor the mixers and measurers, and on the third floor the hoppers for cement, sand and gravel. The cement was stored in large shed holding 40 to 50 car loads, and was raised to the top by an elevator and dumped into metal lined chutes leading to measurer.

Four side dumping cars loaded by the ordinary hoist with sand or gravel from flats at the river's edge were hauled up an inclined railway, and delivered the material into the hoppers at the top floor.

From these hoppers, the cement, sand and gravel passed separately into a measurer of special design; this consisted of a heavy four armed casting, revolving slowly inside a cylindrical shaft, providing compartments of the proper size, which alternately filled with material and dumped it into the "worm mixer" below. As the mixture was moved along in the mixer, water was added in small amounts and the concrete then passed into a chute with gate at lower end, whence it was taken by wheel-barrows wherever wanted.

This mixer was erected in triplicate, it being the original intention to run at least two of them at once, with the third for reserve. It was soon found, however, that one alone could turn out concrete faster than it could be taken away by wheel-barrows below, and much faster than it could be deposited properly—hence more than one mixer was rarely run at once, but the others were used to give different mixtures, and as a reserve.

This plant, although largely experimental, did good service, turning out on some days over 500 cubic yards per day of 20 hours, when that amount could be used, and making a total of about 20,000 cubic yards.

As compared with the more common cube mixer, the "worm" mixer has the advantage of being continuously in action, which is desirable when a wheel barrow gang is used, and having great capacity, the mixer itself requiring very little at-

tention ; when vertical space is limited, it can be compacted in much less space than cube mixer. It is liable, however, to break or become clogged, unless carefully designed, and requires more power.

The following table gives the cost of mixing concrete by "worm" mixer, as estimated from actual experience during the past year :

Cost of Materials.....	1-4-10	1-3-8	1-2-5
American Portland Cement @ \$2.05 per bbl ,	\$1 37	\$1 69	\$2 66
Sand @ 2½c per bu.....	0 30	0 29	0 29
Gravel @ 2c per bu.....	0 38	0 38	0 37
	<hr/>	<hr/>	<hr/>
	\$2 05	\$2 36	\$3 32

Cost of delivery to Mixer of materials..... \$0 07

Cost of measuring and mixing..... 0 05

Cost of delivery 150 ft. and return by wheelbarrow

gang 0 23

Cost of tamping..... 0 18

Total cost of Labor, \$0 53

(The above represents the average of an ordinary day's run but does not include share of cost or depreciation of mixer plant.)

An American Portland cement was used throughout, mixed with sand and gravel in proportions varying from 1-3-8 to 1-2-5 ; no broken stone was used as actual tests on concrete blocks showed that an equally strong concrete could be secured at lower cost by the use of gravel alone.

The concrete was usually very wet when deposited, principally for the reason that the sand was very wet as it came out of the flats ; this, however, was not considered an objection, in spite of the fact that test blocks of dry concrete rammed very hard showed 20 to 40 % greater strength than wet concrete of the same mixture.

In the first place, in large masses, concrete is never rammed as thoroughly as in test block, and dry concrete is weak unless thoroughly rammed, while wet concrete can be put in without so much labor and attention, in considerable depths at a time, without appreciable loss of strength. With wet con-

crete the bonds between old and new work are stronger, in fact a proper bond can not be made without slushing wet mortar over the face of the work already in. In actual work, in large masses, wet concrete is preferable to dry, both in point of cost of deposition and the ultimate strength of the work as a whole.

The walls and engine foundations proper, were also built of concrete, and a few words as to cost of forms will be of interest.

In the walls of the engine room basement, of a height of 16 feet, and average thickness of over 3 feet, the cost of forms was not over 20 cents per cubic yard exclusive of bracing for the bank, which was a very variable factor, inasmuch as with either brick or masonry this bracing would still have had to be erected, the concrete was cheaper, more convenient, and better.

A very safe and easy method of putting in foundation walls in dangerous places, is to dig trench where wall is to be, bracing it as in sewer work, then fill it with concrete, and later excavate the interior without need of bracing of any kind. This plan was tried with marked success in construction of storage battery building in East Liberty recently; adoption of this plan in the work under discussion to-night, would have rendered excavation much less difficult and expensive.

Each engine foundation contains about 350 cubic yards, and is quite complicated in shape. In brick work, this would have cost at least \$6.00 per yard, while the actual cost in concrete was \$0.50 for material and labor in erecting and removing the forms, and \$4.00 for the concrete itself.

In the construction of the various trenches and tunnels, with numerous bolts and other things to be built in, the concrete was so easily deposited and gave such excellent results, that its use would be justifiable even if it were not cheaper.

Even for a small boiler foundation, it is cheaper to build the forms and use concrete, than to build it in brick work. These statements, of course, refer only to machine-mixed concrete; hand-mixed concrete is usually much more expensive.

The steel frame work of the building was furnished by Jones & Laughlin, and is shown on the cross sections. The specifications called for open hearth steel of tensile strength 60,000 to 65,000 pounds, elastic limit not less than 35,000—22 per cent. elongation, 40 per cent. reduction in area, and not to exceed .04 of 1 per cent. of either phosphorus or sulphur. The main feature of interest is a coal bin over the boiler room, the sides being made of plate girders 10 feet deep and 19 feet apart, the floor being supported by 12 inch "I" beams spaced every 2 feet. This bin is designed to hold five tons of coal per lineal foot, or total of about 1,200 tons, in addition to the 1,500 or 2,000 tons which can be stored in the coal storage room. The coal will be dropped to the boiler fronts by means of chutes opening from bottom of coal bins.

The exterior of the building is of Pompeian brick, with Cleveland sand and stone trimmings; the interior of the engine room is Pompeian brick with enameled brick wainscoting and slate cap. The finish is quartered oak throughout, and the floor is a mosaic floor known as "granito" with slate border.

The interior of the boiler room is common red brick; the roof is cinder concrete with iron stiffening bars (John A. Roebling's Sons Construction, system B, Type 1), with felt and crushed slag embedded in pitch on the upper surface.

The coal bin is plastered on expanded metal inside, and slated outside.

Coal is to be received by rail via either A. V. R. R. or P. J. R. R., and dumped into hopper under ash bin at river end of boiler room. It passes through an automatic weigher into the buckets of the Mead Conveyor underneath, is elevated about 50 ft. and passes along under the coal bin, being dumped anywhere it is desired. Conveyor then passes on and down into the tunnel beneath the boiler room, and when not carrying coal may be used to carry ashes from ash hoppers, along tunnel to the ash bin at river end of building.

When it is wished to store coal, the chutes leading into

coal storage room are opened, the coal being obtained again when wanted by passing down into conveyor in tunnel, and being again hoisted to upper coal bin. The conveyor can handle 40 tons per hour, and takes about 15 horse power to operate. When the plant is doubled, another line of boilers takes the place of the present coal storage room with second engine room beyond, and a new place for coal storage will then have to be provided on the unoccupied river front.

The boilers are Babcock & Wilcox water tube boilers of special design, there being six batteries of two boilers, of nominal rating 375 H. P. each.

The boilers are shorter and higher than the usual type (in order to economize floor space), having three 36 inch drums 20 feet long and 18 sections of 13-4 inch tubes each giving about 4,000 feet of heating surface.

Hawley Down Draught Furnaces are used, having a grate surface of 60 square feet.

The pressure carried is 125 lbs., the boilers having been tested under hydraulic pressure to 300 lbs.

The Hawley Furnace is guaranteed to show 10% greater efficiency than the ordinary flat grate, and to be able to burn 40 lbs. of coal per square foot of grate per hour, with prevention of 92% of the smoke.

At 25% above rating one man can handle battery of two boilers; the boilers are guaranteed to develop 75% efficiency with the Hawley Down Draught Furnaces, with less than 1% of moisture at full load or $1\frac{1}{2}\%$ at 50% above rating. In the acceptance test the above guarantees were obtained.

Each battery of boilers has an iron stack unlined, 66 in. in diameter, and rising 147 feet above the grate bars, giving a draught of 1 in. to $1\frac{1}{2}$ in. of water under ordinary conditions.

The boilers are fed by three Worthington Duplex Direct Acting Feed Pumps, capable of lifting 240 gallons per minute 20 feet, and delivering it against a pressure of 160 lbs.

The pump plungers are bronze and are outside connected.

Water may be taken either from the city mains from the intake pipe, or from the hot well, and after passing through the pumps on its way to boilers, passes through small heater, receiving the exhaust steam from the pumps.

The feed piping is of brass throughout, and is in duplicate at front and rear of the boilers.

The steam piping is of cast steel throughout. Each boiler is connected to 20 in. steam main from which the engine connections are tapped off.

Expansion is provided for by two large copper expansion bands; no attempt is made to provide duplicate steam pipe.

The engines are made by the Ponna. Iron Works of Philadelphia, and are of very massive and plain design, the high pressure cylinder being 36 inches in diameter; the low pressure 54 inches, and the stroke 48 inches.

The two bed plates for the high and low pressure sides are each made in one casting. The two main bearings being 20 inches in diameter, and 40 inches long.

All piping is beneath level of engine room floor.

The normal speed at full load is 80 R. P. M., 82 at no load, and 77 at 50% overload—the speed not to rise above 86 if the latter load be suddenly thrown off.

Corliss valve gear used, both high and low pressure admission being governed. A large re-heater is placed between two cylinders.

The pressure on the crank pin is less than 400 pounds per square inch at full load; on cross head pins is less than 800.

The fly wheel is 20 feet in diameter and weighs 100,000 pounds.

Lubrication is accomplished by an oil pump. A jet condenser is used with direct connected differential air pump, of interesting design, calculated to maintain 25 inches vacuum at 50 per cent. overload, when the overflow water is being forced out under 10 foot head.

The pump is a differential double acting pump of 10 inches

stroke, having a $20\frac{1}{4}$ inch plunger in tandem with 30 inch piston on either side. This gives a discharge of about 2 cubic feet on both up and down stroke from each side.

The pump buckets, delivery plates, trunks, etc., are of bronze. The bolts, nuts and washers are of Tobin bronze.

A counter balance is attached to outer end of pump.

The engine is expected to furnish a K. W. hour at switchboard with steam consumption of about 22 pounds.

The engine room has a large electric traveling crane, made by Pawling & Harnischfeger, of Milwaukee, the span being $52.7\frac{1}{2}$ inches, travel about 250 feet, capacity 90,000 pounds at 5 feet per minute, the maximum lift being 40 feet.

The dynamos are standard Westinghouse 550 volt railway generators, of nominal 800 K. W. capacity, the armature being pressed on to engine shaft by pressure of more than 125 tons; during a continuous run at full load or one hour's run at 50 per cent. overload, no part of the machine shall rise more than 40° centigrade above temperature of surrounding air.

One of the novel features of the plant is the interlocking pneumatic switchboard furnished by the Westinghouse Company. It is the first application of this kind of apparatus to railway work, although somewhat similar to the alternating current switchboard of the Cataract Construction Company at Niagara Falls.

All the machine and feeder switches and circuit breakers are controlled by air valves on ornamental iron stands on a platform raised above the engine room floor.

The bus bars, switches and other apparatus are in the vault below, and the air valves interlock in such a way that mistakes in manipulation are hardly possible.

Each Generator has a generator stand on the upper platform provided with an Am-Meter, Hand Wheel for regulating the potential; a Volt Meter connection, a tell-tale lamp showing when Circuit Breaker is out, and the two air valves, one controlling the main switch, and the other the circuit breaker.

Each Feeder Stand has a similar equipment, with the exception of the Rheostat and Volt Meter connection. In addition, there is a Volt Meter Stand and an Am-Meter Stand, each carrying 3 Weston Instruments, and lighting stand controlling the lights throughout building.

The feeder connections are 1,000,000 Circular Mills lead covered cables which run through conduits in the basement from the switchboard vault, to a cable vault in a corner of the building, thence through a tunnel 435 ft. long under the A. V. R. R. freight yard into conduits, again to man holes at 20th Street and Penn and Liberty Avenues, where the connection to the overhead feeders is made.

When the two remaining units are installed the cost per horse power installed will be about \$70.00, without taking into allowance the fact that foundations for an equal number of boilers have been provided in addition.

The discussion of this paper was voted postponed until the next meeting. A vote of thanks was voted to Mr. Greenwood and to the Consolidated Traction Company for their courtesies, and the members adjourned to the power house of the Consolidated Traction Company, Mr. Greenwood having kindly furnished cars for the members.

The building and equipment was thoroughly inspected, and formed an enjoyable wind-up to the evening.

REGINALD A. FESSENDEN,
Secretary.

MEETING OF CHEMICAL SECTION.

The regular monthly meeting of the Chemical Section was held December 22d, in the rooms of the Society's house, 410 Penn avenue, Pittsburg, Pa. Chairman, J. O. Handy. Attendance 12.

The minutes of the last regular meeting were read and approved. J. M. Camp, for the nominating committee reported the following nominations for officers for 1899 :

Chairman—Dr. E. S. Johnson.

Vice Chairman—Dr. Walther Riddle.

Directors—W. E. Garrigues and J. O. Handy.

Secretary—A. G. McKenna.

A letter from James Brakes, giving his methods of analysis for forge irons, was read by the secretary and followed by an informal discussion.

The paper for the evening, on "Fluctuations in the Composition of Natural Gas, and on a Method for the Determination of Nitrogen in Gas Mixtures," was then read by the author, Dr. F. C. Phillips.

FLUCTUATIONS IN THE COMPOSITION OF NATURAL GAS; AND A METHOD FOR THE DETERMINATION OF NITROGEN IN GAS MIXTURES.

BY FRANCIS C. PHILLIPS.*

At the mills and factories of the Pittsburgh region the opinion is often expressed by men in charge of steam boilers where natural gas is the fuel used, that the gas fluctuates in its heating power, and at certain times more gas must be used than at others in order to accomplish the same work. Changes of pressure in the mains, owing to varying demands upon the supply, requiring that the valve controlling the admission of gas to a boiler fire should occasionally be opened more widely, might readily lead to the supposition that the gas, at such times, possesses less heating power and consequently a different composition.

No data as regards results in practice have been obtainable, but in analyses of gas from various wells in the Pittsburgh region, reasons have been found for supposing that slight fluctuations actually occur in its composition. With a

*This paper was presented in somewhat different form to the American Academy of Arts and Science, in Boston, October 12, 1898, and acknowledgment is here made of aid received from the C. M. Warren Fund Committee, of the Academy, in conducting the experiments described.

view to a more complete study of the subject, the experiments described in this paper were carried out.

As regards the character and number of its chief constituents, natural gas differs widely from coal gas and from gas manufactured in the various forms of gas producers. While in artificial gas unsaturated compounds are present in great variety, natural gas is composed mainly of the hydrocarbons of the paraffin series, associated with very small quantities of nitrogen, carbon dioxide, and water vapor. The olefines, represented mainly by ethylene, are found sometimes in extremely minute proportions, so minute, in fact, that quantitative determinations are a matter of difficulty, although they are qualitatively recognizable when large volumes of gas are employed. Traces of organic sulphur compounds are present in some instances. Free hydrogen, carbon monoxide, hydrogen sulphide and oxygen do not occur.

It is a difficult matter to single out any of the constituents of natural gas as specially suited for a series of determinations, having for their purpose to ascertain whether fluctuations actually occur in its composition. One of its constituents—nitrogen—seems to be less prone than the others to enter into chemical changes locally in the rocks, and therefore less likely to undergo diminution in the original gas, as it is stored in the interstices of the sandstones and limestones of the Devonian formation. It might be proper to begin such a study with nitrogen.

Under the term nitrogen is here understood the incombustible residue obtained when natural gas is burnt in such manner as to prevent the admixture of air or oxygen with the products. That the element nitrogen is actually contained in natural gas has been frequently shown by passing the gas over heated magnesium. The magnesium, on being afterwards moistened, yielded ammonia, recognizable by its odor and reactions, and indicating the presence of nitrogen in the original gas.

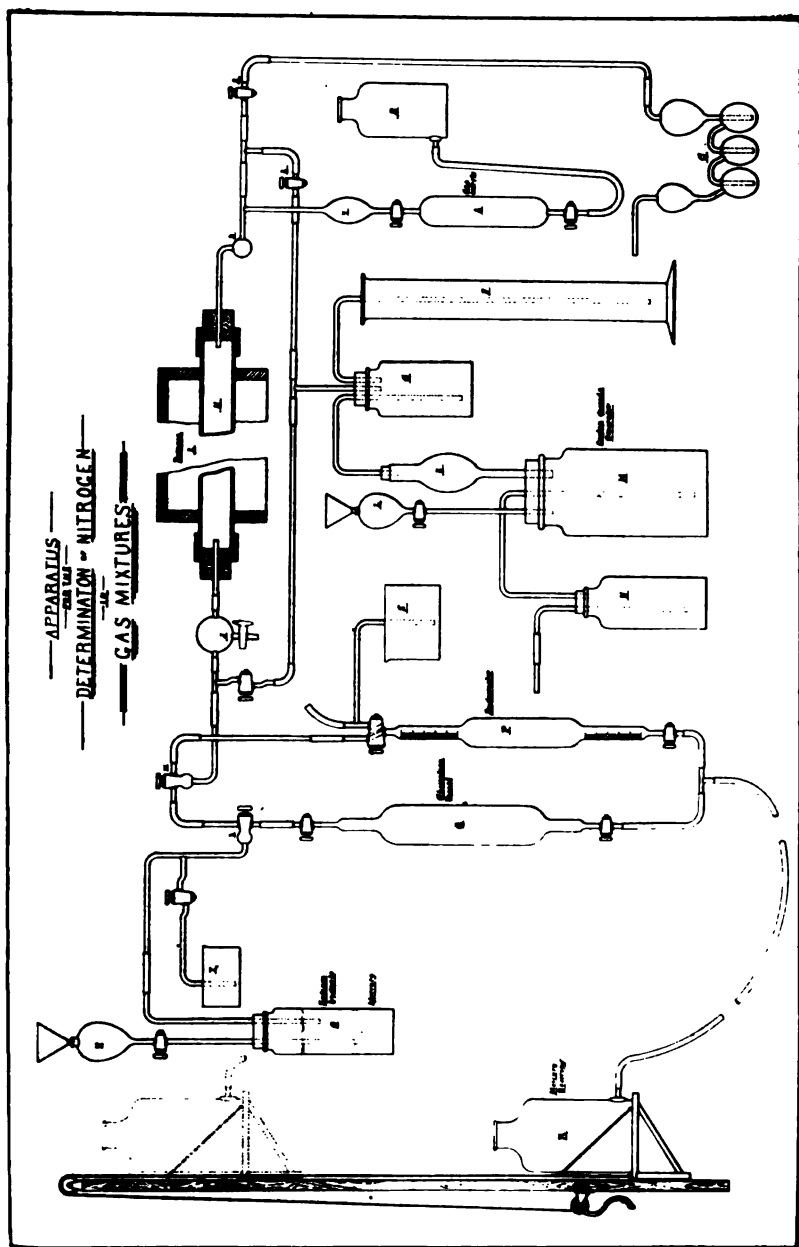
The method employed for the determination of nitrogen consisted in burning a measured volume of natural gas by passing it over heated copper oxide. The resulting steam was condensed and the carbon dioxide absorbed by potassium hydroxide solution, leaving the residual nitrogen to be measured over mercury. This adaptation of the Dumas method has been proposed by Stöckman for the determination of nitrogen in coal gas.* Arth has described an apparatus for a similar purpose, the gas measurements being made over water.†

DESCRIPTION OF THE PROCESS.

The gas sample was collected in a glass cylinder of from 150 to 400 cc. capacity, and having stopcocks at both ends. In the drawing of the apparatus, *A* represents the gas sample vessel with its stopcocks and capillary endings. Vessels of 150 cc. proved sufficiently large for the determination, although in the later work, where it was desirable to collect a larger volume of the residual incombustible gas, vessels of 350 to 400 cc. were used. These vessels were calibrated by weighing the mercury required to fill them. They were filled with gas, as it flowed directly from the well in all cases, except that of the gas supplied to Allegheny, which was drawn from the mains in the laboratory. The filling was done under slight excess of pressure, the gas being allowed to flow through the vessels for at least ten minutes before the stopcocks were closed. With a view to determining by calculation the volume at 0° and 760 mm. pressure of the contained gas, the vessels, after the return to the laboratory, were placed vertically in a large box having glass sides, and in such a position that the lower stopcock projected through a thick rubber disk, set in the bottom of the box and having an opening just large enough for the stopcock to pass through it. The gas cylinder stood erect inside the box, being held by a clamp, while its lower stopcock projected below and was accessible from beneath. The

*Zeitschrift für Analyt. Chemie, 1875, p. 46.

†Bull. Soc. Chim., 1897, p. 30.



temperature in the box was indicated by a thermometer, which could at all times be read through the glass panes. When this temperature had remained constant for at least one hour, the lower stopcock was opened for an instant, allowing the surplus gas to escape. A glass tube, connected by rubber joint with the lower stopcock, and just touching, but not dipping under, the surface of the water in a beaker, afforded a safe and simple means for preventing the possibility of the entrance of air during the equalizing of the pressure. After opening and shutting the stopcock, the pressure of the contained gas was assumed to be that of the air outside, as indicated by the barometer. A drop of water was always introduced into the sample vessel before it was filled with gas, so that the gas could be regarded as saturated with moisture when used for analysis.

The gas vessel was connected with a mercury bottle *B*, the capillary tubes at the ends of the cylinder having been filled with mercury before the connections were made. By raising the bottle *B* and opening the stopcocks, the gas was slowly driven over from *A* through the glass tube *VII* into the porcelain combustion tube *III*, which contained a layer of heated copper oxide forty centimeters long. The porcelain tube was heated in a combustion furnace, (partly shown in sketch). The products of combustion of the gas passed by way of the glass bulb and the stopcocks *W* and *X* to the absorption vessel *Q*, in which the carbon dioxide was absorbed by solution of potassium hydroxide. This solution was delivered over when needed from the bottle *O*, by pouring mercury into the tapfunnel *U*. The residue of gas, after the absorption of the carbon dioxide in *Q*, was then caused to return by the same route to the cylinder *A*, by adjusting the mercury levels in the reservoirs *B* and *R*. A third passage of the gas over from *A* to *Q* rendered it certain that all hydrocarbons were completely burnt. The bulb *J*, and the combination of bulb with three-way *DVI*, served to condense and hold as water any steam

due to burning of hydrogen of the gas in the combustion tube, and to prevent its return into the heated porcelain tube. These bulbs proved very necessary to overcome danger of breakage. The stopcock on the bulb *J* served to discharge this condensed water. As it was necessary to rinse the porcelain tube and its glass connections, after the passage of the gas from *A* to *Q*, or from *Q* to *A*, this was accomplished by means of a slow stream of carbon dioxide, generated by the action of concentrated hydrochloric acid upon calcite, in the large jar *M*. This jar contained about five pounds of calcite at starting. The escaping carbon dioxide passed through fragments of calcite in the tube *K*, and through water in the bottle *G*. From this wash bottle, the gas stream could be deflected to the right-hand end of the combustion tube, as seen in the sketch, entering this tube by the stopcock *Z* in rinsing gas into the absorption vessel *Q*, or to the left, by way of the stopcock *ZZ*, in rinsing gas back into the vessel *A*. In this manner the rinsing out of the products of combustion into either *A* or *Q* could be made very complete. The tube descending into water in the open cylinder *FF*, served as a safety valve to permit the escape of surplus carbon dioxide from the generator, and thus any unsafe pressure in the apparatus was avoided. The carbon dioxide could, therefore, be generated freely and utilized only in so far as it was needed. It is to be observed that the long glass tube connecting the stopcocks *Z* and *ZZ* lies in the same horizontal plane with the combustion tube *III*, although in the sketch it appears lower, in order that the arrangement of parts may be rendered clear. The carbon dioxide having been absorbed in *Q*, the residual gas was ready for measurement, which was accomplished in the eudiometer *P* over Mercury. The eudiometer was of one hundred cubic centimeters capacity, being made very short as shown (about forty centimeters long.) It was graduated only in its uppermost and lowermost portions. This is a convenient form

of eudiometer where mercury is used, as it avoids the great pressure due to a high mercury column, and consequent danger of leakage through stopcocks, so common where a high column of mercury is used. It is easily seen that by lowering sufficiently the bottle *R* any volume of gas, up to 100 cc., may be readily measured. The combustion furnace stood somewhat higher than the upper end of the eudiometer. It was surrounded closely by sheet iron sides, which served to carry upward the waste heat. No difficulty was experienced in maintaining a constant temperature about the eudiometer, as indicated by a thermometer reading to 0.05° , placed in contact with its sides. By reason of the strong upward draught produced by a sheet iron box placed around and in close contact with the sides and ends of an ordinary combustion furnace, much may be done towards diminishing the discomforts of the experimenter, while the temperature of the interior of the furnace is increased, and the ends of the combustion tube are more readily kept cool. The tube *tt*, dipping into water in the beaker *S*, served to discharge the absorption vessel after a determination. In a similar manner the eudiometer may be discharged of its contents by the tube *ss* dipping into the beaker *S*. The tube *K* served to discharge carbon dioxide through a Liebig bulb having a water seal, when the apparatus is being cleared of air, preparatory to a determination. The various forms of stopcocks used are sufficiently indicated by the sketch. The time required for a nitrogen determination was from one and a half to two hours, when 150 cc. of gas were used. Two or three days were sometimes occupied, however, in expelling the last traces of air from the apparatus by the slowly passing carbon dioxide stream preparatory to a series of determinations. It may be mentioned that the preservation of a constant temperature in the neighborhood of the eudiometer was further promoted by having a ventilator set in the ceiling of the room, over, but somewhat to one side, of the furnace, in order to carry off the heat.

The potassium hydroxide solution was of 1.258 specific gravity, as recommended by Kreussler,* and the measurement of the nitrogen was always made with a little of the fresh solution resting upon the mercury in the eudiometer. The mercury reservoirs were attached to supports sliding vertically in wooden frames (not shown), and the reservoir connected with the eudiometer could be adjusted by screw movement so as to bring the mercury in the reservoir and that in the eudiometer to the same level. Readings were made by an accurate cathetometer. Pressures of mercury columns were all calculated at 0°.

A very high temperature was found to be necessary for the complete combustion of the hydrocarbons of natural gas, under the conditions of the method, the carbon dioxide produced causing retardation. No difficulty was experienced, however, as repeated experiments demonstrated that the residual gas did not contain carbon monoxide or free hydrogen. In the course of a determination, three passages of the gas took place through the copper oxide—from *A* to *Q*, from *Q* back to *A*, and from *A* to *Q* again—before final measurement of the residue. It was repeatedly found that, on passage for a fourth and fifth time through the copper oxide, and absorption of the carbon dioxide, no further reduction of volume was produced. The constantly-increasing amount of reduced copper in the porcelain tube, as combustion goes on, serves to prevent the escape, undecomposed, of any oxides of nitrogen, should such compounds tend to form during the process.

In order to procure pure carbon dioxide for the Dumas method of nitrogen determination in organic bodies, it has been recommended that the marble to be used be first pulverized and then boiled in water before its carbon dioxide is liberated by the action of an acid. Berntsen† frees the pores of the marble by exhaustion with an air pump. In experi-

*Zeitschrift für Analyt. Chemie, 1885, p. 445.

†Zeitschrift für Analyt. Chemie, 1882, p. 68.

ments tried, with a view to producing pure carbon dioxide, these methods have not proved altogether satisfactory. The carbon dioxide stored in steel cylinders was tried. It was found, however, that the gas leaves a considerable volume of unabsorbed residue, when treated with a solution of a caustic alkali. Sodium carbonate was tried instead of marble. A hot saturated solution of the salt was allowed to crystallize in the generator and the mother liquor poured off. The carbon dioxide produced by the action of an acid upon the crystals so obtained is purer than that produced from marble, but the evolution of the gas is tumultuous and uncontrollable. Experiments were made with marble from various localities, but with little success. A marble from Tate, Georgia, was found to yield very pure carbon dioxide after it had been coarsely pulverized and well boiled in water. Another sample of apparently the same rock, from the same locality, yielded after similar treatment a small residue of gas unabsorbed by potassium hydroxide solution. A calcite from Lampasas, Texas, in translucent cleavable crystals, was found to yield satisfactory results. The mineral was crushed coarsely, boiled for six hours in water, and then transferred with a portion of the boiled water to the generator. The carbon dioxide evolved proved to be very pure. Experience has shown, however, that no reliance can be placed upon calcite or marble as a source of carbon dioxide, because a specimen of apparently the same mineral known to come from the same locality has proved satisfactory. It was found necessary to test each batch separately, as regards the purity of the carbon dioxide which it evolves.

To overcome the danger of the action of strong alkali, upon stopcocks in such work, it was necessary to use an unsaponifiable lubricant. After numerous trials it was found that a mixture, consisting of 7 parts melted pure rubber and 3 parts unbleached beeswax, the whole being softened with a little vaseline, served the purpose quite well, protecting the

stopcocks completely. More than 150 determinations have been made in the same eudiometer without accident to stopcocks.

Some difficulty was experienced in expelling air from the copper oxide when the apparatus was being prepared for work. In beginning a series of determinations, several days were often required for the purpose. The porcelain tube was strongly heated, while a slow stream of carbon dioxide was maintained, and the copper oxide was not considered to be in proper condition for use until the escaping carbon dioxide was found to be absorbed without residue by potassium hydroxide solution. About 300 cc. of escaping gas were used for the trial. When the copper oxide was freed from air, determinations of nitrogen in natural gas could follow each other until, from experience, it was shown to be necessary to reoxidize the partially reduced copper oxide. About ten determinations could be made before this reoxidation was needed. Regeneration of the copper oxide was affected by drawing air through the apparatus while hot. It was found that the copper oxide when once impregnated with carbon dioxide, *while strongly heated*, could be reoxidized by an air current, with very little tendency to occlusion of air. After the passage of air for a few hours, a stream of carbon dioxide readily expelled the remaining air and the apparatus was again ready for further determinations. But if the copper oxide was allowed to cool in contact with air, much time was lost in removing the air by the current of carbondioxide, even when strong heat was applied during the process. It appears that little or no occlusion of air occurs when the copper oxide is *previously impregnated with carbon dioxide*, while the same substance exposed to air in the cold occludes the air and holds it with much persistence.

SELECTIONS OF SAMPLES OF GAS.

Many of the wells are drilled through several different gas producing sandrocks, separated by deep layers of imperv-

ious shales and other strata. The gas from these different sands mingles, and the product flowing from a single well is often a mixture of gas from formations many hundred feet apart in the geological scale. It was attempted, as far as possible, in the present work, to secure samples from wells yielding gas from a single sand rock. It was desirable that the samples be taken from wells situated at no great distance from the laboratory, in order that as short a time as possible should elapse between the collection of the sample and the commencement of the analysis.

RESULTS OF DETERMINATIONS OF NITROGEN.

1. Gas well at Shields, 14 miles West of Pittsburgh. This well was drilled in 1892, and yields gas exclusively from the fourth sand, which was reached in drilling at a depth of 1,760 feet.

Date of Collection of Samples.	Percentage of Nitrogen Found.
August 5, 1896.....	(1) 1.25
	(2) 1.26
February 5, 1897.....	(1) 2.70
	(2) 2.67
	(3) 2.68
April 6, 1897.	(1) 1.79
	(2) 1.80
April 20, 1897.....	(1) 1.85
	(2) 1.85
June 1, 1898.....	(1) 1.10
	(2) 1.10

2. Well on the Anderson farm at Sewickley, 12½ miles West of Pittsburgh. This well was drilled in 1894, and yields gas exclusively from the third sand, which was found at a depth of 1,850 feet.

Date of Collection of Samples.	Percentage of Nitrogen Found.
July 7, 1896.....	(1) 2.48
	(2) 2.50
August 14, 1896.....	(1) 1.72
	(2) 1.71
March 22, 1897.....	(1) 2.11
	(2) 2.10

3. Well on the Miller farm at Glenfield, Pa., $9\frac{1}{2}$ miles West of Pittsburgh. Drilled in 1887. The gas is produced mainly from the fourth sand, although a little gas finds access to the well from the upper sands. The fourth sand was reached in this well at a depth of 1,800 feet.

Date of Collection of Samples.	Percentage of Nitrogen Found.
July 27, 1896	(1) 1.52
August 17, 1896.....	(1) 1.69
	(2) 1.69
April 2, 1897	(1) 3.24
	(2) 3.25
April 16, 1897	(1) 3.23
	(2) 3.21
April 28, 1897	(1) 3.23
	(2) 3.20
May 4, 1897.....	(1) 3.20
	(2) 3.22
April 8, 1898	(1) 2.10
	(2) 2.10
April 21, 1898	(1) 2.12
	(2) Lost
June 9, 1898.....	(1) 1.27
	(2) 1.30
June 13, 1898.....	(1) 1.23
	(2) 1.22

4. Well on the Bayley farm, Neville Island, in the Ohio river, $6\frac{1}{2}$ miles west of Pittsburgh. The well was drilled in 1892. Gas is derived from the "Thirty-foot" sand alone, which was found at a depth of 1510 feet.

Date of Collection of Samples.	Percentage of Nitrogen Found.
August 1, 1896.....	(1) 1.46
	(2) 1.48
April 12, 1897.....	(1) 2.10
	(2) 2.11
April 24, 1897.....	(1) 2.10
	(2) 2.09
May 27, 1898.....	(1) 1.49
	(2) 1.48

5. Well on the Hamilton farm, Neville Island, in the Ohio river, 7 miles west of Pittsburg. The gas is derived

from the Third Sand, which was reached in drilling at a depth of 1580 feet, although there was a slight flow of gas from the Fifth Sand, which was reached at 1729 feet. The well was drilled during the spring of 1898. The first samples of gas below mentioned was taken about 24 hours after the gas had been turned into the mains.

Date of Collection of Samples.	Percentage of Nitrogen Found
May 16, 1898.....	(1) 1.78
	(2) 1.76
May 19, 1898.....	(1) 1.74
	(2) 1.74

6. Well on the King farm at Murrys ville, 18 miles east of Pittsburgh. The gas is derived from the Murrys ville Sand at a depth of 1336 feet. The well was drilled in 1887. Analyses of samples taken on a single late are presented, but this gas is of especial interest, on account of the fact that the Murrys ville gas field was among the earliest explored. The wells of the region are now nearly exhausted. The pressure in the rock has fallen from about 500 pounds to so low a point that at certain seasons of the year, when the demand is greatest, the gas is regularly pumped from the wells into the mains. Pumping was not being practiced when the samples were taken.

Determinations of nitrogen in samples collected June 6, 1898, gave :

- (1) 1.29
- (2) 1.28

7. Another well on the same farm at Murrys ville yields gas exclusively from a sand about 100 feet deeper. Gas collected on the same date from this well was found to contain the following percentages of nitrogen :

- (1) 1.38
- (2) 1.40

8. Well on the Souder farm, 12 miles west of Buffalo, N. Y. This well was drilled in 1892, and yields gas from the Trenton Limestone exclusively. Mr. E. Coste, Engineer for

the Provincial Natural Gas Company of Buffalo, is authority for the statement that the drill passed through the base of the Trenton Limestone at a depth 30 feet below the point at which the gas was obtained. Hence the horizon from which this gas comes is extremely low in the geological scale as compared with the productive formations of the Pennsylvania gas fields.

Samples were collected at this well on September 3, 1896. The percentages of nitrogen found were as follows :

(1) 4.57

(2) 4.55

9 Well on the Reinhart farm, near Sherkston, Canada, 10 miles west of Buffalo. In this well the gas is derived solely from the Clinton Limestone, which was reached at a depth of 590 feet. Determinations were made in the case of samples collected on September 1, 1896. The percentages of nitrogen found were as follows :

(1) 3.64

(2) 3.61

10. Well No. 12 of the Provincial Natural Gas Company at Sherkston, Canada. Gas is derived solely from the Medina Sandstone, which was reached at a depth of 850 feet.

Samples were collected on September 1, 1896. Percentage of nitrogen found :

(1) 5.17

(2) 5.10

In the case of all these Canadian wells, the gas samples were shipped to the laboratory directly after their collection, and the determinations made without delay. All the samples so far mentioned were taken directly at the wells. Several determinations of nitrogen have been made in the case of natural gas from the mains supplying Allegheny. This gas was derived from various wells scattered through a region of considerable area.

Date of Collection of Samples.	Percentage of Nitrogen Found.
August 25, 1896.....	(1) 1.48
	(2) 1.50
August 26, 1896.....	(1) 1.52
	(2) 1.52
August 28, 1896.....	(1) 1.56
	(2) 1.54
August 31, 1896.....	(1) 1.52
	(2) 1.52
February 28, 1898.....	(1) 1.93
	(2) 1.99
March 9, 1898.	(1) 1.30
	(2) 1.31

Careful tests for oxygen were made in the case of gas from the mains, as there seemed to be a possibility of access of air to the gas. The method of testing consisted in causing the gas to bubble through a solution of manganous sulphate, contained in a small Woulfe's bottle provided with a tap funnel, through which a little sodium hydroxide solution could be added during the passage of the gas. A change in color of the manganous hydroxide, which was precepitated, would have indicated the presence of oxygen. Tests made in this way were continued frequently for an entire day while the nitrogen determinations were in progress, but no oxygen was found, and hence no air could have gained access to the gas.

There seems to be reason for the assertion that fluctuations occur in the composition of natural gas, but until the study of the subject is carried further, and more data are obtained, no attempt can be made to connect such fluctuations with any known facts as to the geology of gas.

There is some little evidence for supposing that gas from the deeper horizons is richer in nitrogen, and that the older productive wells yield gas containing a little less nitrogen, but such may prove not to be the case when more data are at hand.

It seemed to be of interest to subject the incombustible gas residue, obtained in the preceding work, to further study. Portions of the residue were mixed with electrolytic oxygen,

and subjected to the action of electric sparks. The experiments are still in hand, and their results cannot yet be fully stated. It may be here mentioned, however, that the gas submitted to this treatment yields oxides of nitrogen, and in presence of potassium hydroxide solution undergoes a considerable shrinkage in volume. There can be no doubt that the residue consists mainly of pure nitrogen.

The condition in which natural gas occurs in the rocks—whether as a liquid or as a gas—has always proved an interesting subject for speculation.

If natural gas consisted of methane alone, it could not exist in liquid form inasmuch as the temperature of the rocks exceeds the critical temperature of methane, which cannot be liquified by pressure above—99.5 Centigrade. But, on account of the presence of other more easily condensible hydrocarbons in natural gas, its occurrence in liquified form is not impossible, as the less volatile constituents might serve to hold those which are more volatile in a condition of solution. The critical temperature of methane, which is commonly present in natural gas, is 35° C.

If, as a result of pressure gas exists in liquified form in the pores of the sand rocks, it is probable that when a drill taps the gas-bearing rock, causing relief of pressure, the more volatile of the constituents of the liquified gas would escape in relatively larger proportion, as the gas begins to flow from the rock. The process would be of the nature of fractional distillation, and would tend to the production of a gas especially rich in the most volatile constituent; but the most volatile constituent of natural gas is nitrogen, since all of the hydrocarbons and carbon dioxide would be more readily liquified than nitrogen. The first yield of a well which taps a gas-bearing rock having no other outlet should, therefore, contain a higher proportion, relatively, of nitrogen, and the proportion of this nitrogen should gradually diminish as the liquified gas continues to evaporate. There would result, after a time, a

gaseous mixture containing less and less of nitrogen, and when the reduction of pressure had progressed so far as to permit of the conversion of the least volatile of the constituents into gas, the proportion of nitrogen in the escaping gas would become virtually constant, because the process would then be one of outflow of a gas mixture, and not one of volatilization of an extremely low boiling liquid whose constituents have different boiling points.

The presence of petroleum in contact with natural gas would exert a marked solvent action.

It is a well-known fact that when coal gas is compressed into iron cylinders, a portion of the more readily condensable hydrocarbons is liquified, and as the pressure upon the contained gas is increased, the illuminating power is diminished. At pressures of ten atmospheres and above, the value of the gas as an illuminant may in this way be seriously affected.

If the pressure is relieved by opening the valve, the condensed hydrocarbons begin to evaporate, and their vapor again enriches the gas.

What occurs on a small scale in the cylinder of gas at moderate pressures, might take place on a much greater scale under deep-lying and impervious rock strata, where pressures many times greater exist.

The rock pressure in the Pennsylvania natural gas fields has in rare instances attained to 1,000 pounds per square inch. Some cases are reported in Northern New York State where rock pressures of 1,500 and 2,000 pounds have been measured. Such pressures are probably the highest ever observed in any natural gas field, but such pressures would be incapable of liquifying nitrogen or methane at any temperature likely to exist in the rocks. Should further determinations of nitrogen furnish evidence that a gradual diminution in the proportion of nitrogen is in progress, support would be given to the view that a change from the liquid to the gaseous state occurs before the gas escapes from a drill hole.

My acknowledgments are due to Messrs. H. C. Beggs and A. G. Edwards for aid in conducting the experiments described.

After discussion of the paper, the Section adjourned at 10 p. m.

A. G. McKenna,
Sec. C. S.



PROCEEDINGS

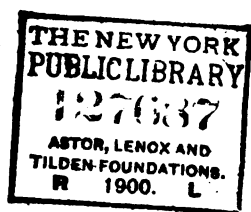
—OF—

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

PITTSBURGH, PA.

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VOL. XV.
—

1899.
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ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The Nineteenth Annual Meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the Society's House, 410 Penn avenue, Pittsburg, Pa., Tuesday evening, January 17, 1899, the president, Mr. Geo. S. Davison, being in the chair and 40 members and visitors present.

The meeting was called to order at 8:25 and the minutes of the preceding Annual Meeting of January 18, 1898, were read and approved.

The following report was read by the Treasurer :

REPORT OF TREASURER FOR THE YEAR ENDING JANUARY 17, 1899.

1898.	RECEIPTS.		
January 18.	Balance.....	\$	39.64
	Dues to January, 1895.....	1.....\$7.00...	7.00
	" " 1896.....	1..... 5.00...	5.00
	" " 1896.....	2..... 7.00...	14.00
	" " 1897.....	4..... 5.00...	20.00
	" " 1897.....	5..... 7.00...	35.00
	" " 1898.....	9..... 5.00...	45.00
	" " 1898.....	21..... 7.00...	147.00
	" " 1898 $\frac{1}{2}$ yr... 2.....	3.50...	7.00
	" " 1899.....	48..... 5.00...	240.00
	" " 1899 $\frac{1}{2}$ yr... 1.....	2.50...	2.50
	" " 1899.....	240..... 7.00...	1680.00
	" " 1899 $\frac{1}{2}$ yr... 3.....	3.50...	10.50
	" " 1900.....	1..... 5.00...	5.00
	" " 1900.....	3..... 7.00...	21.00
	Initiation Fees.....	27..... 5.00...	135.00
	On Account.....		8.00
	Rent of Rooms in Society House.....		974.00
	From Advertising Contracts.....		78.00
	From Sale of Proceedings.....		94.15
	Special Contribution to Library.....		3.00
	Total		3,531.15
			<u>\$3,570.79</u>

EXPENDITURES.

Rent.....	\$1,500.00
Salaries.....	650.00
Printing.....	649.30
Office Expenses.....	214.05
Illustrations.....	90.03
Binding.....	75.30
Permanent Improvements.....	59.00
Gas.....	56.10
Stenographer.....	39.50
Repairs.....	33.42
Water.....	56.18
Cleaning Rooms and Carpets.....	28.84
Periodicals.....	22.00
Insurance.....	20.00
Lunch for "Smoker".....	20.50
Commissions.....	12 50
Stereopticon.....	8.00
<hr/>	
Total.....	3,534.72
Balance.....	36.07
<hr/>	
Total.....	\$3,570.79

Respectfully submitted,

A. E. FROST,
Treasurer.

It was voted that the report be accepted, with the thanks of the Society.

The following report was read by the Secretary :

REPORT OF THE SECRETARY FOR THE YEAR ENDING
JANUARY 17, 1899.

Membership at close of year ending Jan. 18, 1898.....	365
At the Annual Meeting, Jan. 18, 1898, there were thirteen (13) names dropped from the roll, one (1) of whom was later reinstated.....	12
There were fifteen (15) resignations and one (1) death reported during the year.....	16
<hr/>	
	28
During the year two (2) of the applicants elected members in 1897 matriculated ; and thirty appli- cants were elected members of the Society during 1898, and of these twenty-four (24) matriculated...	26 2
<hr/>	
Membership at close of year ending Jan. 17, 1899.....	363

The average attendance at the monthly meetings of the Society during the year was forty-six (46).

It was voted that the report be accepted.

The President stated that the applicants who would be voted on that evening and those who would be recommended by the Board of Direction, aggregated 21 new members for the first meeting of the year.

The Board of Directors recommended the expulsion of eight members for non-payment of dues.

It was voted that the names read be stricken from the rolls.

Mr. Wilkins for the Auditing Committee reported that they had audited the accounts of the treasurer and found them correct.

It was voted that the report be accepted and filed.

Mr. C. B. Albree reported as follows for the Library Committee :

“Your committee, during the past year, has re-arranged and classified the books on a simple system, so that all books relating to a given subject are found together. To permit of future expansion, it seemed best to designate books by a label indicative of the contents, rather than by an arbitrary system of numbering, hence it follows that all the books on a given topic have similar labels, and are found together on the shelves. If a member is looking for information on any topic, it is easier for him to have all the works on the subject directly before him, rather than have to look up a catalogue to find the number and location of the works desired. Further, in this latter case he would have to know the names or authors in order to find the locations.

There are six main classes :

Class A. Works of Reference.

Class B. Transactions of Societies and Bound Periodicals.

Class C. General Non-technical Literature.

Class D. Economics and Commerce.

Class E. Natural Science and Mathematics.

Class F. Applied Science, Industrial Arts and Engineering.

These main classes are sub-divided into main topics (indicated by Roman numerals), and these are further sub-divided, the subsequent sub-divisions being indicated by Arabic numerals. To illustrate: If a book is marked F-II-3-7, it would show, first, F, Applied Science and Engineering; second, Roman II, Mechanical Engineering; third, Arabic 3, Power Transmission; and, finally, Arabic 7, Hoisting and Conveying.

The general classification will be printed and copies furnished to all members. In addition, placards have been placed over each case, giving an outline of the classification of books in the particular cases.

Owing to the great number of Society Transactions and Bound Periodicals, as well as to the great size of some of the latter, it was deemed best to utilize the lower parts of the various cases for the periodicals. As there are many of them so general in contents that they could not well be classified, the placards mentioned, state in full the names of the Society Transactions and Periodicals in the cases under each placard.

It is hoped that the members, in using the Library, will replace books in their proper sub-division or place, when through with them.

The proper cataloguing of our Library, either by the card system or by a printed list, would not now be a difficult, although a rather tedious, work. The actual user of the Library would hardly need such aids, but were a printed catalogue published, each member could have a copy on his desk, and ascertain at once whether the work he wanted was on our shelves, without having to examine the cases personally, perhaps only to find it was not there.

In making this classification, the committee finds that there is a great lack of modern, up-to-date works on engineering topics. While it may be desirable to retain the old works, as of historical interest, yet, as most of our members are

practical, up-to-date men, it is hoped our finances may be such that the needed books can be added.

It is probable that many members have duplicate copies of modern books, that they would be willing to donate to the Library. It is earnestly requested that any member having such books will send a list of them to the Secretary of the Society, and a messenger will be sent for the books, if our Library does not contain them already.

There has accumulated, during the past year, a great number of periodicals that should be bound and placed in their respective divisions. The Committee would like to have authority to order this done.

The Library is open all day and until about 10 p. m. in the evenings. While the Library room, itself, is not heated or lighted, as a rule, yet members can at any time get books they require, and bring to the sitting room in front, which is always well lighted and heated.

It was voted that the report be accepted, and the recommendations be referred to the Board of Direction for action."

The President then read his Annual Address.

ANNUAL ADDRESS

OF

PRESIDENT GEO. S. DAVISON.

Another page in the history of this Society has been written, and as we open to a new page to-night, it is certainly with no misgivings as to what will be written upon it. The keen interest in the Society's affairs, that is held by such a large number of its members, means that its high standard as a technical organization will be maintained, and the list of its officers for the coming year is a sufficient guarantee that good counsel shall always prevail, and that its affairs will be administered with great zeal, intelligence and honesty.

In the nineteen years of its existence, this Society has taken no backward step. It has been confronted with grave

questions at times, some of them affecting its very existence, but all have been decided with rare good judgment. Honest differences of opinion among its members have shown forth in debate, but gentlemanly courtesy has always prevailed. There have been no sudden changes in its policy, no costly experiments tried and relinquished; neither have there been any internal dissensions, those rude shocks that prove to be the death blow to so many organizations.

The objects of the Society are concisely and clearly stated in the charter, and are three in number, namely: the advancement of engineering in its several branches, the professional improvement of its members, and the encouragement of social intercourse among men of practical science. How well have we lived by these declarations, which no doubt were framed and subscribed to by the charter members with many misgivings as to the outcome of their venture! Let us inquire.

The advancement of engineering in its several branches! This statement recognizes that broad field of usefulness, that reaches from pole to pole, from the depths of earth and sea to that farthest point in space to which the aided vision of man may penetrate. The mind may conceive its boundaries, but the combined knowledge and skill of many, can but partially unfold its mysteries. The astronomer, the chemist, the electrician, the mineralogist, the geologist, the metallurgist, are only specialists in the field of engineering, and in the ranks of our Society, each and every one of these special branches are well and honorably represented. That the advancement of each of these branches has at least been attempted is evidenced in the fact that in the nineteen years of its existence, the Society has been furnished with more than 200 papers by its members, which papers may be classified by their subject matter as follows: Those connected with or pertaining to astronomy, two; geology, three; mining, six; manufacture, nine; electricity, nine; mechanical, thirteen; metallurgy, fifteen; description of processes, twenty-four; chemistry, thirty-nine;

engineering, fifty; and unclassified, twenty-six. In addition to these, we have had the published reports of special committees on Rail Joints, on Natural Gas, on Smoke, on Good Roads, and on Pure Water. All of the above papers represent the work of our members, and are the fruits of much labor spent in reviewing and bringing together the best ideas of others and in carrying out original research. They cover in our transactions 4,114 pages of octavo size, printed in small pica type, interspersed to a considerable degree with explanatory plates and photographs. A large number of these papers have been republished in some of the leading technical journals of this and other countries, and through them, have been distributed over the civilized world. But this is not all: we have managed to establish a reference library of more than twenty-five hundred volumes, and our list of current technical journals embraces 95 publications, 16 of them being printed in foreign countries.

To prove that this Society is advancing the several branches of engineering needs no argument beyond a statement of the above facts, and we think that we can safely challenge any technical society in the world to produce as broad a scope of subjects as has been covered by our members.

To answer the inquiry whether our organization tends to improve us professionally, it might be necessary to hold an experience meeting; even then our modesty might prove a hindrance to a proper determination of what we owe to our Society and to each other. In the data given above, it can be seen that the seed has been and is being sown with a lavish hand, and it must be presumed that it has not all fallen upon stony ground. The benefits resulting from the writing of a paper are not confined to the audience that may hear it read. The writer may have considered himself very familiar with the subject at the outstart, but he will find that his effort to convey his knowledge to others, has taught him much that he did not know, and impressed upon his mind to a better advantage what he had already known.

Again, he may surely expect to be set right should he give expression to any false notions or theories, those sirens which occasionally lure the engineer to professional ruin. And still again, if the aforesaid audience thirsts after knowledge to an inquisitive degree, the aforesaid author suddenly finds that, notwithstanding there was a time when he "knew it all," he must plunge deeper into his subject if he wishes not to appear ridiculous. And so, with the history of the healthy growth of this Society before us, we must conclude that there has been some attraction to becoming and continuing a member of it, and its transactions are proof positive that professional improvement has ever been with us.

And what shall we say about the third point, the encouragement of social intercourse among men of practical science, or as I take it, among the members of this Society? This is where we may have failed, or at least made the weakest showing relatively.

I think men of scientific training, as a rule, overlook the importance of the social side of life. Trained to think, to calculate, to plan, they become so accustomed to turning to account every moment of their time, that they come to regard a social diversion in the light of a thief, that may rob them of something they prize most highly. Time does not hang heavily upon them, as it may upon those without occupation, or those whose occupation is of the manual kind, and who, in their unoccupied moments, must find some means of occupying the mind. To this latter, social duties may afford the relief sought. If not, indulgence in a constant round of social pleasures is likely to follow. While they thus reach one extreme, the man of scientific taste and attainments is most likely to remain at the other. If so, he becomes lost in the community where he lives. He takes no part in its political welfare or purposes, and he loses his popularity, if he ever possessed any. This state of affairs follows him to his business. His face and figure may be familiar, but he does noth-

ing to engage the attention of the business world, and so he is forgotten, when his services should be in demand, while to his professional brother, who has not neglected his social duties, come numerous commissions unsought. Meanwhile, this recluse, as we may call him, drifts away from his friends in the profession, and thereby loses the greatest opportunity he should possess of keeping in touch with the current events and practices of the profession. The loss is mutual, but falls hardest upon him, who seeks to go it alone. Business men have their trusts, the trades their unions. The object is to secure that strength that follows the combination of interests, and its consequent financial return. Should the members of a profession combine? They certainly should. Not simply for the system of mutual education that is bound to result from scientific discussions. They should combine socially as well. They should become intimate. They should vie with one another in the display of professional courtesy. Such a course as this would elevate the profession in the eyes of others, and elevation is what we are all seeking. We all agree that engineering talent is not appreciated as it should be, and that consequently it is greatly underpaid. We are inclined to show our feelings when we note that other professions are more favored in this respect than we are. What is to be done? Shall we impress our importance upon the public by increasing the charges for our services? That would have no other result than to reduce the demand for our services in the future. With every other man on the face of the earth believing himself to be well up in engineering, and that it is only for lack of time that he does not do his own work in that line, the chances of services for *the engineer* are few enough now. Do not let us reduce these chances. Rather let us unite in the laudable work of proving to the public at large that engineering is a profession, and a profession of no mean order; that every man in its ranks is a gentleman, notwithstanding his intelligence. See to it that when we speak of our brother engineer, that we find no fault

in him. Let his reputation be held sacred when in our hands. Let us perform every service so conscientiously and well, that we shall become indispensable, no matter what our charges may be. Let us not stand aloof from our profession, nor take the opportunity of belittling any one in it, with the idea that by so doing we can accomplish our own selfish ends. Such a course may bring us success, but it is success dearly bought. We will have besmirched the character of those who should be our best friends, and dealt a staggering blow to a struggling profession, that loaned us its name when we were so poor that we had nothing to put up as collateral. If we are weak and sorely tempted, how can we be made proof against such actions? I answer, in that social intercourse so happily recognized in the charter of this Society. Come out and mingle with each other, and find out what really good fellows we all are. There will be found no exceptions. And when we feel the warm grasp of friendship, and look into that honest face behind it, we will have something to pattern after, something to respect, something to which to be loyal.

Now do not take what has been said as a reflection upon what we have or have not done. It is only my purpose to illustrate, as best I can, that social intercourse among us is a most important element to the success of the Society, of our honorable profession, and consequently of ourselves. Therefore, if upon self-examination we find that we could do nothing more in this direction than has been done, let us do it, that every stated object of this Society be carried out in the fullest degree.

After scanning what we have done among ourselves, and suggesting matters of mutual benefit, it is eminently proper to turn our eyes outward and consider our relations with the community in which we are located and of which we are an integral part. We will find that our Society has usually been among the first to recognize public necessities, to study those necessities, disseminate information about them, and make suggestions for the benefit of the people at large.

When natural gas began to play such an important part in the economies of Western Pennsylvania, this seemed to be the only favored spot on God's footstool, and little or nothing was known of that wonderful agent of heat and power. As it came from the hidden recesses of the earth, it did not appeal to the senses of man, except possibly that of smell, and the extent of its deposits could only be conjectured. Up to fifteen years ago, although natural gas had been used for many years prior to that, ignorance of it and skepticism about it had prevented its general use. And then, when capitalists did take hold and place it within reach of the consumer, its dangerous properties seemed to so greatly outweigh its usefulness that it was exceedingly slow to gain favor. Just at this time, our society became intensely interested in the subject, and appointed a most able committee to investigate its properties and gather all the information that was to be had. That this committee performed its appointed task well, can be understood when, fifteen years after its report was printed and given to the scientific world, to-day that report stands as one of the most exhaustive papers upon that subject, and one that in the meantime has done much to cause the general use of this free gift of nature, and thereby brought warmth and gladness to many.

The construction and maintenance of the highways of the people are engineering problems, but among those whose interests are most affected by the condition of the public roads, this fact is not generally recognized. That good roads are badly needed throughout the grand old commonwealth of Pennsylvania, as well as other states that may not be so grand, is well recognized. But while a recognition of this long-felt want dates back several generations, there has been little accomplished to give the people what they want and should have. It has not been the sovereign will of the people that they have been allowed to wallow in the mud until they are broken in health, spirit and pocket-book. It has been the lack of prompt,

heroic and intelligent legislation on the subject by our law makers at Harrisburg. I mean to lay great stress upon the adjectives, for while it would appear that the average legislator is keen and quick-witted in politics, and very energetic in gathering in the succulent fruit when the plum tree is shaken by ministering angels, his ignorance on subjects of practical utility is pitiable and his apathy toward them is criminal. At the session of the legislature ten years ago, this apathy was so far removed for the time being, that some legislation, having good roads for its object, appeared imminent. Members scrambled over and trampled upon each other in their eagerness to present their ideas, until the machinery of that session became clogged with proposed worthless measures. Out of this mass of confusion, nothing was being accomplished, for while commendable zeal had seized the representatives of the people, intelligence remained a stranger unto them. At this juncture, our society appointed a committee to examine into the sundry laws pending and, if possible, bring something practical out of the chaos. This committee reviewed the entire subject from the fundamental principle of good road making, to the drafting of an act which was conceded to embody the best plans for the organization of the forces necessary to construct and care for good roads that was brought to the attention of that legislature. While the discussion of the subject of the various road laws suggested continued to be the principal feature of that session, nothing was accomplished, but it aroused great public interest, which was maintained for several years after and in which this society sustained an honorable part.

The one great barrier to cleanliness, health and happiness among the people of this otherwise favored locality is the smoke laden atmosphere. Prior to the very general use of natural gas, it was considered a necessary evil. With the great falling of in the supply of gas, king coal came to rule once more, but he wore a grimy visage that could not be tolerated after such a season of cloudless skies, and clean shirt

fronts as we had just experienced. What shall be done to rid us of the stain on our character, has been one of the most important topics before the people. This Society appeared early in the discussion and made it the subject of an extended report, and did its full share in causing city ordinances to be passed for the reduction of the nuisance. That this reduction has not materialized has not been the fault of the laws, so much as the failure to enforce the same, and we are again in the throes of revolutions against smoke. This time the Chamber of Commerce has taken the lead and has asked our Society to appoint some of its members to a joint committee to see what can be done to cleanse the atmosphere. The President of the Chamber has already named the gentlemen who will represent it, and if this Society completes it, it will be found that every member of the proposed joint commission is a member of this Society. The personnel of that portion of the committee already appointed is a pleasing recognition of this Society and the efforts that it has put forth in behalf of public welfare in the past.

Within the past few years, the medical profession has determined that typhoid fever, that dread disease that has brought so many to an untimely grave, is but a "war to the death" between the forces of the human body and a mighty host of infinitesimally small bacteria, and that the enemy gains access to the seat of conflict mainly through the means of contaminated water. With the cause and effect thus determined, it was evident that victory over the disease laid more in precautionary measures than in medical skill. The alarm must be given, the people educated up to the point of self protection, and means devised for obtaining pure and wholesome water for domestic use. The large death rate from typhoid in Pittsburg and Allegheny cast strong suspicion upon their water supplies. The Chamber of Commerce, the Allegheny County Medical Society and the Engineers' Society of Western Pennsylvania joined together through a joint committee for the purpose of educating the people on the necessity of pure water, and re-

porting on the most feasible scheme for obtaining it. After this Commission had organized and mapped out the method of procedure, it was found that all the work fell upon a few of the doctors, and the members of this Society, of which, members of the Chemical Section were an important part. At a great sacrifice of their time and money, these gentlemen performed their work. That work has borne fruit, and, after a lapse of five years, a substantial recognition of those services is about to be made in the reception by the city authorities of another report on the same line, but obtained at the expense of more than \$10,000. We do not know as yet what the findings and recommendations of this last report will be, but we predict that in a few days that report will demonstrate the wisdom, completeness and correctness of conclusions of the other report. One gratifying circumstance of to-day is, that among the persons who are connected with the so-called Filtration Commission, and who are clamoring loudly for pure water, are some of those who ridiculed the idea of the Commission of five years ago and went to great lengths to prove, by chemical analysis, mark you, that the water supplied the people of Pittsburg was absolutely pure. But, poor creatures, they are not to blame. It was not a matter of opinion with them in either case. It was a matter of politics only. It was good politics to believe our water supply of five years ago to be perfect. It is good politics to condemn it now. Let us be thankful that it so happened that the last opinion came after the first, rather than vice versa.

And while were we are on the subject of politics, it might not be amiss to consider the relation it bears to the engineer. The citizen or a business man employing engineering talent may, and generally does recognize true merit, and award the proper recognition to it. Politics do not work on any such plan. The professional man must be kept down. He must be kept out of sight. His intelligence would require the politician to at least share honors with him, if it did not rob him

of his power entirely. Witness the conduct of our own city government. When the necessity and size of a proposed bond issue for public improvements are to be determined, when the location of new union stations, which depend on the engineering problems involved, are to be made, when the city authorities need a committee on consultation for the abatement of smoke nuisance, when a scheme for a pure water supply, involving the expenditure of millions of dollars, is to be decided, do they say to the dear people? "We will appoint from among your number a committee, who by reason of their knowledge of the subject and every day's experience are eminently qualified to give an opinion, who will forward that opinion to you, without prejudice, but with fearlessness and honesty." No, they do not. The result might prove embarrassing. They simplify matters, by themselves formulating all the opinion that the people need to hear. Then a few citizens, prominent only from the fact that they have been successful in business and that they have been used in that capacity so often before, are appointed, and in star chamber session are fitted to the desired opinions, very like a misfit is adapted to some use, rather than sacrifice it entirely. Note the official title of that learned body, who has been studying bacteriology, that the people of Pittsburg might be edified on the point of how and where they will get a drink of pure water. How does it happen that it was named the "Filtration Commission?" Surely this name, given to them before they begun their investigation, which was supposed to embrace every plan for obtaining pure water, smacks very largely of the idea that they were expected to find for the plaintiff, without reference to the testimony. And mark my words, they will. Not that it will be an improper finding in this case, but the entire work of the Commission would have carried less suspicion with it had it been called "Pure Water Commission," or some such title. And that leads me to mention a much greater offense that has been committed against the professional talent of this city.

And that was the choice of the persons who were to conduct the scientific part of the work of this same commission. I have no fault to find with the ability of the gentlemen who performed those services, and so far as I know they have committed no act against professional courtesy, and are above criticism, but with all due respect to them, all the talent necessary for the solution of the problems involved was to be found among the citizens of Pittsburg, and I hope I may be pardoned when I say that I am capable of passing judgment on that point. Owing to the relations I have sustained from the first discussion of pure water for this city, it takes some courage to make the above statements, and I may be misunderstood, but I make them now and in this public manner, that it may be known that there is at least one person who has a high opinion of the ability of the members of this Society, both engineers and chemists, and also of the members of the medical profession in this city. And while others are clamoring for Greater Pittsburg, that through such consummation we may impress our importance upon the outside world, and that every article of home manufacture may go to the consumer without a question as to its quality, because forsooth it was made in Pittsburg, I say that home talent should be exhausted before the imported article is consulted, if the glory of Pittsburg is to be made complete. Who makes the noted specialist for New York or Chicago? Not himself. One man never does, nor never will "know it all." The opportunity made him. His neighbors made him. A friend of mine went to New York to consult a highly-advertised specialist in surgical operations. Arrived there, the latter made an examination of the case, and he asked him whom he had consulted in Pittsburg. When the name of the local doctor was given, (and that name was not known outside of his own practice), the would-be patient was told to waste no time with any one in New York, but go back home and place himself under the care of his own physician, as there was none more skillful than he. This was the opinion of

a man so skilled himself that it was his privilege to pass judgment, and what was better still, no case of skill on his part could have placed him so high in the estimation of my friend as that unselfish act of professional courtesy.

Other large cities lend their fame and name to their own professional men by giving them the opportunity to display their knowledge and skill when such knowledge and skill is in demand. Why should not Pittsburg do the same? Why should her prophets be without honor in their own country? Her industries are carefully fostered, on the principle that the exports should exceed the imports. Why should this rule not apply to her professions? And where is there a more appropriate place to practice it than in the government that represents her people?

Looking back over the past year, and without attempting to single out any special accomplishments of the engineer in civil life, we can see, that, as usual, he has gone ahead and prepared the way for the advance of mankind. The water we drink, the food we eat, the light that makes the night as day, the sanitary measures for our health, the comforts of travel, all have again felt the touch of the engineer; and, while resting or traveling, while at work or at play, the world has enjoyed the fruits of his genius. But it is not in the paths of peace that the engineer of 1898 has won the greatest renown. For fifteen years the engineer connected with the American Navy had been quietly planning and experimenting, constructing and equipping. The only attention he attracted was the jibes and criticisms of foreigners, who had had so much use for implements and vessels of war that they were naturally given the credit of being posted on such matters, and they, on their part, were inclined to presume on their reputation. In their patronizing way, we were informed that our vessels were slow, and that our guns were too small. That was a reflection on our engineers' brains. But lo! that was not the worst of it. Should the product of his brains ever be

required in actual warfare, no matter how weak the foe, he would lack the courage and skill to use them. With silence our engineer endured all these reflections upon his ability and courage, and his heart was heavy as he perceived that these foreign notions were shared in by his own countrymen, from whom he had a right to expect words of sympathy and praise instead. But his hour of triumph has come. The past year will be notable for the proof of the fact that while the American engineer is one of the greatest elements of peace, his brains and courage can defend a nation, and where the world stopped to ridicule him, they stayed to applaud. American pluck and energy has built the grandest nation in the history of the world. American statesmanship has shaped its course through years of doubt and impending disaster, but it was left to the American engineer to win for it universal admiration and a wholesome respect for it from all nations, that will be its safeguard for all times. We are proud of him! He is our brother.

The President announced that the next order of business would be the election of officers for the ensuing year.

The President announced candidates for offices reported by the nominating committee, as follows: President, H. J. Lewis; Vice-President, H. W. Fisher; Directors, P. T. Berg, F. C. Phillips; Secretary, R. A. Fessenden; Treasurer, A. E. Frost.

Mr. Crooker, Chairman of the Nominating Committee, in answer to a question by Mr. Engstrom, stated that all of the gentlemen nominated had been notified and had consented to serve.

On motion of Mr. Engstrom it was voted that nominations be closed and that the Society proceed to ballot.

The President appointed Messrs. Johnson and Koch as tellers.

Upon counting the ballot the tellers reported that the

candidates had each received 26 votes, and the President declared them duly elected.

The following is the list of officers and members of committees for the year 1899-1900 :

OFFICERS FOR 1899

GENERAL SOCIETY.

PRESIDENT.

HARRY J. LEWIS.

VICE PRESIDENTS.

W. A. BOLE,
Term expires 1900.

H. W. FISHER,
Term expires 1901.

DIRECTORS.

C. F. SCOTT,
Term expires 1900.

P. T. BERG,
Term expires 1901.

GUSTAVE KAUFMAN,
Term expires 1900.

F. C. PHILLIPS,
Term expires 1901.

SECRETARY.

REGINALD A. FESSENDEN.

TREASURER.

A. E. FROST.

CHEMICAL SECTION.

CHAIRMAN.

E. S. JOHNSON,

VICE CHAIRMAN.

WALTHER RIDDLE.

DIRECTORS.

J. O. HANDY, W. E. GARRIGUES.

SECRETARY.

A. G. McKENNA.

STANDING COMMITTEES.

PROGRAMME COMMITTEE.

D. ASHWORTH, Chairman,
W. R. MARDEN,

E. K. MORSE,

C. B. ALBREE,
SELWYN M. TAYLOR.

HOUSE COMMITTEE.

G. W. SCHLUEBERG, Chairman,
F. Z. SCHELLENBERG,

C. W. RIDINGER,
CHAS. FITZGERALD, O. C. OPSION.

LIBRARY COMMITTEE.

RALPH CROOKER, Jr., Chairman,
PHILO. KEMERY,

E. S. McCLELLAND,

THOS. FAWCUS,
G. C. URQUHART.

RECEPTION COMMITTEE.

WILLIAM BRADFORD, Chairman,
E. F. WENDT,

HENRY F. MILLER,

G. C. LANGENHEIM,
SAMUEL A. TAYLOR,
R. A. ROLAND, JOHN M. PHILLIPS.

The retiring President called Mr. Bole, first Vice-President, to the chair, in the absence of the newly elected President.

PROF. FESSENDEN—Before this meeting adjourns I would like to say that for a number of years I have seen some of the best members of the Society serve in the various offices, and after their terms of service were over, we have often lost their presence and counsel at the subsequent meetings of the Society.

I wish to ask if it is not possible that something should be done to hold the services of these members. Could not past presidents be made honorary members of the Board of Directors?

When we come to consider the new Constitution I would like to see some provisions made for our retiring presidents.

Upon motion the Annual Meeting adjourned.

R. A. FESSENDEN,
Secretary.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The one hundred and ninety-first regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the Society's house, 410 Penn avenue, Pittsburg, Pa., Tuesday evening, January 17, 1899. The meeting was called to order by the President, Mr. George S. Davison, forty members and visitors being present.

The minutes of the preceding meeting were read, and, after amendment by the insertion of the statement that a vote of thanks was passed to Mr. Greenwood, for the invitation given at the close of the last meeting to visit the power house of the Consolidated Traction Company, and for furnishing cars for the purpose of transporting the members thither, were approved.

For the Board of Directors, the following applicants were reported as passed and to be voted for at the next regular meeting :

RALPH ALBREE,	-	-	Partner of Chester B. Albree, 187 Western Ave., Allegheny, Pa.
D. HERBERT CHESTER,	-	-	Pittsburg Sales Manager, for Henry R. Worthington, 317 Third Ave., Pittsburg. Pa.

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- LOUIS M. HARTWICK, - Mechanical Engineer and Draughtsman,
with Mackintosh, Hemphill & Co.,
268 Fisk Street,
Pittsburg, Pa.
- WILLIAM J. KNOX, - - Chemist,
for Geo. Westinghouse,
820 Penn Ave.,
Pittsburg, Pa.
- JAMES P. LEAF, - - - City Engineer,
at Rochester, Freedom and Monica,
Rochester,
Beaver Co., Pa.
- B. E. V. LUTY, - - - Editor of *Tin and Terne*, and Mgr. of
Pittsburg Office of *Iron Trade Review*,
53 Ninth Street,
Pittsburg, Pa.
- CHAS. S. PRICE, - - - Acting Gen. Supt.
Allegheny Valley Railway,
Eleventh and Pike Sts.,
Pittsburg, Pa.
- W. E. SNYDER, - - - Mechanical Engineer,
with Schoenberger Steel Co.,
Penn Ave. and Fifteenth St.,
287 North Avenue,
Allegheny, Pa.

The following gentlemen were balloted and duly elected to membership :

- J. B. BRENEMAN, - - - Analyst, with the
Duquesne Chemical Laboratory,
336 Fourth Ave.,
Pittsburgh, Pa.
- WM. CLIFFORD, - - - Mining Engineer,
232 Fifth Avenue,
Pittsburgh, Pa.
- JAMES GAYLEY, - - - With Carnegie Steel Co., Ltd.,
Carnegie Building,
Pittsburgh, Pa.
- HARRY W. GIBSON. - General Contractor,
No. 27 Fifth Avenue,
McKeesport, Pa.

- THOMAS G. HAMILTON, - - Steel Railway
Construction Engineer,
5912 Margaretta Street,
Pittsburgh, Pa.
- C. K. LAWRENCE, - - M. W. Union Railroad,
1006 Carnegie Building,
Pittsburgh, Pa.
- JOS. R. PATTON, - - General Contractor,
4737 Maripoe Avenue,
Pittsburgh, Pa.
- WILLIAM B. PHILLIPS, - Editor of the
American Manufacturer,
59 Ninth Street,
Pittsburgh, Pa.
- JAMES LEE RANKIN, JR., - Draughtsman,
Carnegie Steel Co., Ltd.,
334 South Highland Ave.,
Pittsburgh, Pa.
- KENNETH O. P. REINHOLDT, Ass't to Chief Engineer,
P. B. & L. E. Railroad,
1309 Carnegie Building,
Pittsburgh, Pa.
- R. R. RICHARDSON. - - Supt. Transportation,
Duquesne Steel Works
and Blast Furnaces,
Carnegie Steel Co., Ltd.,
Duquesne, Pa.
- RALPH V. SAGE, - - Engineer,
at Keystone Bridge Works
of Carnegie Steel Co., Ltd.,
126 Graham Street,
Pittsburgh, Pa.
- WILLIS WHITED, - - Engineer,
with Keystone Bridge Works
of Carnegie Steel Co., Ltd.,
286 Main Street,
Pittsburgh, Pa.

It was voted, in view of the lateness of the hour, that the discussion of Mr. Greenwood's paper be postponed until the next regular meeting.

Mr. Davison stated, on behalf of the Sanitation Committee, that he had nothing to report.

Mr. Wilkins stated, in behalf of the committee appointed to interview the Congressional representatives and urge them to support the Naval Bill, that his committee had not been able to see the Congressmen personally. The Society then, by vote, instructed the Secretary to write to the Congressmen, informing them that the bill had received the indorsement of the Society, and requesting them to use their influence in having it passed.

The report of the Committee on Power, being both a lengthy and important report, was held over until the next meeting, it being voted to have it read by title and printed in the Proceedings of the Society.

Mr. Engstrom called attention to the delay in issuing the Proceedings.

The Secretary stated that the chief cause of delay was the dilatoriness of the author of one of the papers for the September meeting in sending in proofs, and that the printers' strike was a further cause.

Mr. Davison then read the following letter :

CHAMBER OF COMMERCE OF PITTSBURG.

JOHN BINDLEY, President.

GEO. H. ANDERSON, Sec'y and Sup't.

December 27th, 1898.

MR. GEO. S. DAVISON,

Pres. ENGINEERS' SOCIETY,

Pittsburgh.

DEAR SIR :

The Chamber of Commerce having appointed a special committee on "Abatement of Smoke Nuisance," also request that your Society appoint a committee of five persons to act in conjunction with ours.

Members of the Committee from the Chamber are as follows :

Col. T. P. Roberts, Chairman.

A. E. Hunt.

W. L. Scaife.

D. Ashworth.

S. Diescher.

Hoping for your favorable action in the premises,

Very truly yours,

GEORGE H. ANDERSON,

Secretary.

After considerable discussion, the following resolution was passed :

“Resolved, That the Engineers’ Society of Western Pennsylvania, acknowledge the compliment paid it by the Chamber of Commerce, in asking it to appoint a committee of five members to be a part of a joint committee, on abatement of smoke, and that it considers it advisable to appoint a committee from its own Society to deal with this subject. This committee, however, will be instructed to co-operate as far as possible with the committee from the Chamber of Commerce.”

The subsequent discussion brought more in evidence the fact that the Committee was to be a committee of the Society, and not merely a part of a joint committee ; that it was to report to the Society, and that its members were not to act as consulting engineers for any body, but merely to deal broadly with the scientific and engineering questions involved.

Upon motion, meeting adjourned at 11:30 P. M.

REGINALD A. FESSENDEN,

Secretary.

MEETING OF CHEMICAL SECTION.

The 7th Annual Meeting of the Chemical Section was held January 19, 1899.

Chairman, J. O. Handy.

Attendance 17.

The minutes of the last annual meeting were read and approved.

The Secretary reported that during the year 10 meetings had been held. The average attendance being about 15.

Dr. Phillips, for the Committee on Chemical Literature, reported on the work done by the committee during the year.

The retiring Chairman then read an address on the Treatment of Boiler Waters.

PURIFICATION OF WATER FOR USE IN STEAM BOILERS.

BY JAMES OTIS HANDY.

The troubles which render boiler water purification necessary or desirable, are

1. Corrosion.
2. Scale Formation.
3. Foaming.

Corrosion is caused chiefly by acid waters from coal mines or coal washers, and is made evident by the appearance of red hydrate of iron in the boiler water. When the leaking of the boiler becomes so troublesome that repairs must be made, the tubes and sheets of the boiler are found to be covered with rust and pitted in a manner resembling worm-eaten wood. Many boilers in Western Pennsylvania have been ruined by acid waters. The remedy lies in selecting a new supply, or in treating the water with lime or soda ash, or caustic soda as described later.

Corrosion may also be caused by organic acids contained in waters derived from peaty soils, or it may be due to the decomposition of magnesium chloride under the influence of heat in the boiler. In the latter case there is corrosion of the steam spaces and pipes as described later in this paper. The remedy for all tendency to corrosion is found in the maintenance of a slight excess of alkali in the water at all times. Corrosion caused by the liberation of dissolved gases and by the air is not an important factor except in boilers which are cooled down every night.

SCALE FORMATION.

This trouble is very general and is often taken as a matter of course, no attempt being made to prevent it.

The scale or incrustation forming in the tubes and sheets of the boilers may be hard or soft according as the water which is used contains only carbonate of lime, or both carbonate and sulphate of lime. The former deposits as a spongy coating which would not be adherent were it not for the crystallization of sulphate of lime between the particles of carbonate, thus forming a bond which is afterward made still stronger by the change of the $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ into anhydrite under the influence of the heated plates upon which the deposit has formed.

The rational remedy for scale formation is the removal of the lime compounds by treatment outside the boiler, or the addition of soda ash to decompose the sulphate of lime in the boiler.

Scale allowed to accumulate means loss of fuel, injury to the heating surfaces, expense of cleaning, and danger of explosion.

FOAMING.

The frothing or foaming of water in boilers may be due to one of several causes. Water free from suspended matter will foam if the alkali salts accumulate to 200 grains per gallon. (H. E. Smith, Chemist, C. M. & St. P. R. R., private communication.) Waters containing 75-100 grains of alkali and considerable sludge (precipitated carbonate of lime or magnesia) will also foam. Oily substances introduced into the boiler tend to produce foaming.

In any case the complete remedy is washing out, and the temporary relief is the blowing off of a part of the contents of the boiler and replacing it by fresh water.

The purification of water for use in steam boilers if intelligently carried out, pre-supposes, in the first place, a very inti-

mate acquaintance with the properties and reactions of those substances which render natural waters impure; and in the second place, a clear understanding of the conditions to which the boilers in which treated water is to be used are to be subjected.

The first requisite in any case is a correct analysis of the water, and this is by no means a simple matter. It is not sufficient to determine the total lime and total magnesia and base the proportion of purifying agents on these data alone. The amount of soluble lime, *i. e.*, the lime as sulphate, chloride, and nitrate must be distinguished from the lime existing as carbonate. In the same way, the magnesia as sulphate, chloride, and nitrate must be distinguished from the magnesia in magnesium carbonate. It is not enough to evaporate a measured amount of water to dryness and to treat with hot water. Some CaSO_4 may be left undissolved, and a small amount of CaCO_3 , and a larger amount of MgCO_3 , are sure to be dissolved along with the salts known to be freely soluble. In acid waters the free sulphuric acid and the sulphuric acid existing as sulphate of iron, and in peaty waters the organic acids, must be accurately determined, and this cannot be done unless the influence of acidity due to dissolved carbon di-oxide is eliminated, by thorough boiling.

In short the analyst must ascertain everything of import concerning a water which is to be purified, and having calculated the required charge of purifying agents, he should then make a laboratory trial of the efficiency of his formula.

COMPOUNDS EXISTING IN NATURAL WATERS.

The compounds existing in natural waters and influencing their value for steam making are :

Mud.

Organic Matter.

Silica.

Oxides of Iron and Aluminum.

Carbonate of Lime.
Carbonate of Magnesium.
Sulphate of Lime.
Sulphate of Magnesium.
Chloride of Lime.
Chloride of Magnesium.
Nitrate of Lime.
Nitrate of Magnesium.
Carbonate of Sodium.
Sulphate of Sodium.
Chloride of Sodium.
Nitrate of Sodium.
Free Sulphuric Acid.
Sulphate of Iron.

These may be classified imperfectly as follows :

CONSTITUENTS FORMING SLUDGE OR SOFT SCALE.

Mud.
Silica.
Oxides of Iron and Aluminum.
 CaCO_3 and MgCO_3 .

CONSTITUENTS FORMING HARD SCALE.

Sulphate of Lime.
Hydrate of Magnesia from Decomposition of Magnesium Salts.

CONSTITUENTS PRODUCING CORROSION.

Organic Acids, and Acids Liberated by the Decomposition of Magnesium Salts, notably the Chloride.
Sulphuric Acid and Ferric Sulphate.

CONSTITUENTS CAUSING FOAMING.

Sulphates of Magnesium and Sodium
Chlorides of Lime and Sodium.
Nitrates of Lime, Magnesium and Sodium.
Certain Organic Matters and Mud.

SOLUBILITY OF CaCO_3 , MgCO_3 , AND CaSO_4 .

The accuracy of a water analysis depends on an exact knowledge of these points. The influence of even minute amounts of carbon dioxide in promoting the solubility of the carbonates is well known in theory, but is not usually appreciated or discounted in actual work.

Comey's Dictionary of Solubilities gives the following figures :

1 part CaCO_3 dissolves in 28571 parts of water free from CO_2 , at ordinary temperatures, $=.035$ gms. per litre $=3.5$ parts per 100000.

1 part CaCO_3 dissolves in 1079 parts of water saturated with CO_2 at $0^\circ\text{C}.$ $=0.927$ gms. per litre $=92.7$ parts per 100000.

1 part MgCO_3 dissolves in 5071 to 9438 parts of water free from CO_2 , $=19.7$ to 10.6 parts per 100000.

1 part MgCO_3 dissolves in 45.25 parts of water saturated with CO_2 at $18^\circ\text{C}.$ $=2210$ parts per 100000.

1 part CaSO_4 dissolves in 485.4 parts of H_2O at $15^\circ\text{C}.$ $=206$ parts per 100000.

(My own experience gave me a super-saturated solution containing 622. parts CaSO_4 per 100000, and a saturated solution having 235.7 parts CaSO_4 per 100000.)

At higher temperatures, the solubility of CaSO_4 according to Tilden and Shenstone (Comey's Dictionary) is as follows :

Pressure.	Temperature.	Solubility.
40-lb. gauge.....	286°F or $140^\circ\text{C}.$	0.78 gms. per litre $=78$. parts per 100000
85-lb. "	329°F or $165^\circ\text{C}.$	0.56 " " $=56$. " "
115-140-lb. gauge..	361°F or $175-85^\circ\text{C}.$	0.27 " " $=27$. " "
460-lb. gauge.....	464°F or $240^\circ\text{C}.$	0.18 " " $=18$. " "
535-lb. "	482°F or $250^\circ\text{C}.$	0.16 " " $=16$. " "

As having some bearing on the solubility of CaSO_4 in

water when subjected to boiler temperature and pressure, the writer has found in locomotive boiler waters after various periods of use from 40 to 73 parts of CaSO_4 per 100000.

METHOD OF ANALYSIS.

Determination of Soluble Lime and Magnesia.

“ “ Insoluble “ “ “

“ “ SO_3 , Cl, and Alkalies :

Total Solids, etc.—Clean, ignite, and weigh a platinum dish. Evaporate 500 c. c. of the filtered water, at first over a small, free flame and finally on a water bath, to dryness. Dry for 1 to $1\frac{1}{2}$ hours at 130°C . and weigh. If suspended matter, (clay, etc.), were present in the original water, filter a measured amount of the well-shaken sample through weighed filter paper. Dry paper and residue at 100°C . and weigh. Burn off and weigh to determine organic and inorganic matters in suspension.

Soluble Solids.—Treat the residue in the dish with 50 c. c. of well boiled and still hot distilled water. Cover the dish and boil its contents gently for 5 minutes. Filter, and wash with fresh, boiling hot distilled water, so that the filtrate has a volume of at least 100 c. c. This amount of hot water dissolves readily 60 mg. of CaSO_4 = 12 parts per 100000 when 500 c. c. are taken, more than exists in any but exceptional waters. Acidify the solution slightly with HCl, boil and add NH_4OH in slight excess. Boil for 10 minutes. Filter, if any $\text{Al}_2\text{H}_2\text{O}_4$ has appeared. Wash, ignite, and weigh. Boil the filtrate, add ammonium oxalate in slight excess, boil until the oxalate settles well. Filter, wash, ignite, and weigh CaO. Cool the filtrate in water, add NH_4OH equal to 10% of the volume, followed by Na_2HPO_4 solution, drop by drop, stirring vigorously. Let stand for about three hours, filter, wash with 10% NH_4OH , ignite, and weigh $\text{Mg}_2\text{P}_2\text{O}_7$. Calculate to MgO.

Insoluble Solids.—Pour into the platinum dish 10 c. c. of hot 33% HCl, and after running it all around, pour it on the

original filter which was used for separating soluble from insoluble solids. Receive the solution in a 5-oz. beaker, washing the residue well. Add 1 c.c. of HNO_3 to the beaker contents, and boil for 10 minutes. Add NH_4OH in slight excess and boil for 15 minutes; filter, wash, ignite and weigh Fe_2O_3 and Al_2O_3 .

In the filtrate, determine lime and magnesia as in the soluble portion.

Alkalies.—Evaporate 250 c.c. of water in a platinum dish to about 25 c.c., add about 0.1 gm. $\text{Ba}(\text{HO})_2$ crystals and boil for 5 minutes. Filter and wash with hot water. To the filtrate add $(\text{NH}_4)_2\text{CO}_3$ solution in slight excess, warm and filter. Test the filtrate with $(\text{NH}_4)_2\text{CO}_3$ and if no precipitate occurs, evaporate to dryness, ignite strongly, and weigh alkali sulphates. It is well to dissolve the sulphates in 10 c.c. of hot water and add 1 c.c. of $(\text{NH}_4)_2\text{CO}_3$ solution to test for Ba, which was not precipitated in the presence of the ammonium salts. If any precipitate occurs, add sufficient $(\text{NH}_4)_2\text{CO}_3$ solution, warm and filter. Boil the filtrate, make it just acid with HCl , and precipitate the SO_3 by BaCl_2 solution. Filter through double filters after 30 minutes boiling. Wash well, burn off, and weigh BaSO_4 . Calculate SO_3 and deduct it from the weight of the sulphates. Calculate the proportion of K_2O and Na_2O by the "Stillman" formula:

$$\begin{array}{ll} G = \text{weight of sulphates.} & Y = 1.85 \text{ SO}_3 - .85G. \\ X = \text{K}_2\text{O.} & 0.4387 \\ Y = \text{Na}_2\text{O} & X = (X + Y) - Y. \end{array}$$

SO₃ Determination.—Heat 250 c.c. of water to boiling and determine the SO_3 by making barely acid with HCl and precipitating with BaCl_2 . Filter, wash, burn off and weigh as usual.

Chlorine Determination.—Place 100 c.c. of water in a porcelain dish. Add three drops of potassium chromate indicator and titrate with standard AgNO_3 . Deduct the amount of

AgNO_3 required by an equal volume of distilled water and the same number of drops of indicator.

Free Sulphuric Acid—For analysis, 250 c.c. of acid water is boiled down to about 100 c.c. in a covered beaker. This suffices to expel all the CO_2 . The water is then cooled and titrated with standard sodium hydrate, using phenolphthalein as indicator.

Free Organic Acids may be determined in the same way.

Determination of N_2O_5 .—Evaporate 25 c.c. of water in a porcelain dish to dryness on the water bath. Evaporate also, 2 c.c. of standard KNO_3 solution, equivalent to .00010 gms. N_2O_5 , with 25 c.c. of distilled H_2O to dryness, in a second dish. Cool and treat each residue with 2 c.c. of sulpho-phenic acid (100 c.c. H_2SO_4 + $1\frac{1}{2}$ grams of carboic acid.) Cause the acid to touch all parts of the residue. Dilute to 15 c.c. with water and add ammonia in excess. If the colors are approximately the same, determine the N_2O_5 colorimetrically by comparison with the standard in 75 c.c. glass tubes. If the colors are very different, make up a second lot of standard KNO_3 and after dilution to 25 c.c. evaporate it to dryness side by side with a second 25 c.c. portion of the water. Treat residues as before.

If more than 7 parts of Cl exist in 100,000 of water, the accuracy of the above test is impaired and the Cl must be removed by Ag_2SO_4 free from N_2O_5 .

If organic matter is present, shake a measured volume of water with fresh $\text{Al}_2\text{H}_2\text{O}_4$ and filter, before applying the test.

Determination of Na_2CO_3 Directly.—It seems rather curious that an agent required and often used for purifying water should exist harmoniously in water with the substances which it should theoretically precipitate. This is made possible by the presence of CO_2 in such waters.

Although the Na_2O existing as carbonate may be calculated from the analytical data obtained from the foregoing, it is usually preferable to make a direct titration. Boil 250 c.c.

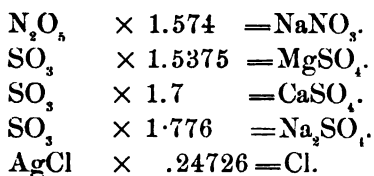
of water with 25 c.c. of deci-normal sulphuric acid, until the solution has boiled down one-half. Cool, and titrate back with standard d.n. sodic hydrate. The difference represents CaO and MgO, existing as carbonates, plus Na_2O as carbonate. Deduct the equivalence of the two former and calculate the remainder to Na_2CO_3 .

CALCULATION OF RESULTS.

If the water contains both CaCO_3 and MgCO_3 (insoluble CaO and MgO), add to the amounts thus found the .0020 gm. CaO and .0040 gm. MgO known to be dissolved by the quantity of distilled water used for separating soluble from insoluble solids. Calculate the insoluble CaO and MgO to carbonates.

FACTORS FOR USE IN CALCULATION.

BaSO_4	\times	.34335	$=\text{SO}_3$.
CaCl_2	\times	.6393	$=\text{Cl}$.
CaO	\times	1.786	$=\text{CaCO}_3$.
CaO	\times	2.93	$=\text{Ca}(\text{NO}_3)_2$.
CaO	\times	2.429	$=\text{CaSO}_4$.
CaO	\times	1.98	$=\text{CaCl}_2$.
Cl	\times	1.65	$=\text{NaCl}$.
Cl	\times	1.34	$=\text{MgCl}_2$.
Cl	\times	1.564	$=\text{CaCl}_2$.
MgO	\times	2.091	$=\text{MgCO}_3$.
$\text{Mg}_2\text{P}_2\text{O}_7$	\times	.7574	$=\text{MgCO}_3$.
MgO	\times	2.362	$=\text{MgCl}_2$.
MgO	\times	2.985	$=\text{MgSO}_4$.
MgCl_2	\times	.7447	$=\text{Cl}$.
$\text{Mg}_2\text{P}_2\text{O}_7$	\times	.3621	$=\text{MgO}$.
Na_2O	\times	2.288	$=\text{Na}_2\text{SO}_4$.
Na_2O	\times	1.7085	$=\text{Na}_2\text{CO}_3$.
Na_2O	\times	2.742	$=\text{NaNO}_3$.
Na_2SO_4	\times	.444	$=\text{Na}_2\text{O}$.
NaCl	\times	.5307	$=\text{Na}_2\text{O}$.
N_2O_5	\times	1.373	$=\text{Mg}(\text{NO}_3)_2$.



The soluble lime minus the deduction for solubility of CaCO_3 is calculated to sulphate, or if there is insufficient sulphuric anhydride, to chloride or nitrate. The soluble magnesia, minus the MgCO_3 deducted, is distributed to the acids in the same way. The soda is then given the same treatment and the remainder of the soda calculated to carbonate. This should agree well with the direct alkalimetric determination.

This method of distributing the bases to the acids is founded on the fact that in general the lime salts are least soluble in water and the magnesia and soda salts next in the order named. This is not true in the case of the chlorides and is questionable in other cases. It is doubtless rational to give the soluble lime the first chance at the SO_3 but it is empirical to say whether the magnesia or the soda shall have the remainder, and whether the magnesia or the soda shall be first combined with the Cl formed. In spite of these uncertainties, the writer favors this method of calculating and expressing results, as it gives one a clearer impression of the probable amounts and combinations of salts in the water that can be obtained by the bare statement of the basic and acid radicals, as determined by analysis.

When calculations of proportions of purifying agents begin, it is only necessary to reckon with the following items :

- Insoluble CaO (CaO in CaCO_3 .)
- Insoluble MgO (MgO in MgCO_3 .)
- Soluble CaO (CaO in CaSO_4 , etc.)
- Soluble MgO (MgO in MgSO_4 , etc.)
- Na_2O in Na_2CO_3 .

and to calculate from each one the amount of purifying agent required.

Before preparing the formula for purification, it is best to consider the reactions which will take place among the salts co-existing in water when the water is subjected to the high temperature and pressure which obtain in steam boilers.

CHANGES OCCURRING IN WATER IN BOILERS.

Upon entering the boiler, the water at a stationary plant has usually been heated by waste steam, so that a part of the dissolved gases have been expelled. In locomotive boilers, the water is not usually pre-heated. As the cold water enters the hot boiler, its dissolved gases are expelled by virtue of the temperature, although the condition of pressure existing in the boiler has some retarding effect on the liberation of the gas. Some corrosion of the metal by the escaping O and CO_2 is generally noticed near the point of entry. Following the expulsion of CO_2 , precipitation of CaCO_3 and MgCO_3 occurs down to the point where they are held in solution by the water alone. After the first day's use of a newly filled boiler, the deposition of CaCO_3 and MgO_3 will beat a constant rate dependent upon the rate of evaporation.

The CaCO_3 and MgCO_3 thus precipitated form at first a loose deposit or sludge, or a loosely adherent crust on the tubes and plates. Frequent blowing off removes most of this sludge, and washings out keep the boiler fairly clean and free from scale if no CaSO_4 is present. MgCO_3 is further decomposed into Mg(OH)_2 and CO_2 . The hydrate, with CaSO_4 , forms a hard porcelain-like incrustation. CaSO_4 , lying as sludge in a boiler, may be acted on by MgCl_2 , forming Mg(OH)_2 and CaCl_2 and CO_2 , or by MgSO_4 forming Mg(OH)_2 and CaSO_4 . The latter change should be guarded against very carefully. Mg(OH)_2 is usually found in boiler scales to the exclusion of MgCO_3 .

CaSO_4 in boiler water is not completely deposited. Tilden and Shenstone's experiments (Proc. Roy. Soc. XXX-VIII. 1885, pp. 331-336), have shown that the popular belief that CaSO_4 is practicably insoluble at temperature above 212

F., is not correct. At 473° F., higher than any ordinary steam boiler temperature, pure water can retain in solution 12.6 grains CaSO_4 per imperial gallon = 18. parts per 100,000. Hence it is probable that CaSO_4 deposits even more regularly than the carbonates, with increasing density of the water. The solubility of CaSO_4 is increased by NaCl up to a certain point. Na_2SO_4 is said to have a similar effect and CaCl_2 the opposite influence. MgCl_2 , at ordinary temperature, increases solubility, but at higher temperatures it diminishes it. A small amount of CaSO_4 seems to have the power of transforming a loosely adherent coating of CaCO_3 and $\text{Mg}(\text{OH})_2$ into a more adherent scale, but an excess of CaSO_4 is necessary to make a really hard scale.

COMPOSITION OF BOILER SCALE.

A hard scale formed on the flues of a locomotive boiler using waters of the average composition :

CaCO_3	—5.87	parts	per	100,000
MgCO_3	— .78	“	“	“
CaSO_4	—4.61	“	“	“
MgSO_4	—2.37	“	“	“
MgCl_2	— .26	“	“	“

was

CaCO_3	— 4.07%
CaSO_4	—83.83“
MgO	— 1.92“

A scale almost equally hard, but somewhat more porous, formed from water having

CaCO_3	—11.91	parts	per	100,000
CaSO_4	— 1.63	“	“	“
MgCO_3	— 1.50	“	“	“
MgSO_4	— 2.93	“	“	“

was of the composition.

CaCO_3	—17.79%
CaSO_4	—63.62“
MgO	— 8.50“

A coarsely crystalline, spongy, or coral-like, friable scale formed from water of

CaCO_3	— 6.43	parts per 100,000.
MgCO_3	— .85	“ “
CaSO_4	— .97	“ “
MgSO_4	— .29	“ “
MgCl_2	— .59	“ “

was of composition.

CaSO_4	— 6.89 %.
CaCO_3	— 85.98 “
MgO	— 4.05 “

Analyses of hard incrustations containing from

0 to 81% CaCO_3 .

1.63 to 67% CaSO_4 .

1.19 to 9.69 % $\text{Mg}(\text{OH})_2$ are given by Fischer, “Chem. Technol. des Wassers.”

Chandler's Analysis of Boiler Scale, (average of six samples from N. Y. C. Ry. locomotives)—

CaSO_4	— 56.49 %
CaCO_3	— 8.11 “
MgO , MgCl_2	— 19.77 %.

CaCl_2 and $\text{Ca}(\text{NO}_3)_2$ are not believed to undergo decomposition under boiler conditions. Concentrated solutions of CaCl_2 have a protective influence on iron.

MgSO_4 in a boiler reacts with CaCO_3 as already stated, forming CaSO_4 , $\text{Mg}(\text{OH})_2$ and CO_2 .

MgCl_2 seems to be an easily decomposable salt. Even at ordinary temperatures, iron corrodes rapidly in neutral MgCl_2 solutions. Under boiler conditions, MgCl_2 is decomposed into $\text{Mg}(\text{OH})_2$ and HCl , which corrodes the iron surfaces, especially those over which the steam travels.

In the presence of air, rusting of iron occurs, in distilled water, in CaCl_2 solution, and more strongly still in solutions of NaCl , KCl , NH_4Cl , and MgCl_2 . The latter acts upon the iron even when CaCO_3 is present. When air is excluded from

the solution containing the iron, rusting does not take place, if NaCl , KCl , BaCl_2 , or CaCl_2 are present. If a solution of pure MgCl_2 is used, the iron becomes black, and after some time the solution reacts acid and contains FeCl_2 .

Fischer's experiments to determine the properties of MgCl_2 solutions under boiler conditions were as follows :

100 gms. C. P. MgCl_2 in one liter of water in a small iron boiler was subjected to a pressure of two atmospheres and boiled for 16 hours, the evaporating water being replaced by distilled water. The steam gave an acid reaction and when the boiler was opened the whole inner surface was found to have been strongly attacked. The iron in the steam space was covered with a thick, reddish brown coating of rust ; below the water line, the metal was clean but indented with depressions like those produced by worms eating into wood. The boiler water measured about 400 c.c., was black with suspended Fe_3O_4 ; it gave a neutral reaction and contained 43 mgs. of Fe_2Cl_6 in 100 c.c. ; 22 gms. of black sludge had formed ; this consisted of Fe_3O_4 , $\text{Fe}_2\text{H}_6\text{O}_6$ and magnesium oxy-chloride. A second research was made in the same manner, except that 90 gms. of zinc rods were introduced into the boiler. This, however, did not prevent the action of the MgCl_2 . By precipitation with soda, the injurious action of MgCl_2 may be overcome.

This completes the list of salts ordinarily occurring in boiler waters and entering into reactions with each other under the influence of the high temperatures to which they are subjected.

CHEMICALS USED AS WATER PURIFIERS.

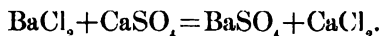
It is proper next to consider the reagents which have been proposed for purification of water. A list comprises :

Hydrochloric Acid,
Barium Salts,
Magnesia,
Alkali Oxalates,
Lime,

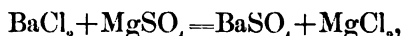
Carbonate of Soda,
Caustic Soda,
Phosphate of Soda,
Fluorides.

Hydrochloric Acid has been employed to purify waters containing bicarbonates of lime and magnesia. If used in excess, it causes much trouble, and its use is restricted, on that account, to certain operations connected with dyeing.

Barium Salts.—It has been frequently suggested that waters containing calcium sulphate can be easily and simply purified by means of BaCl_2 .

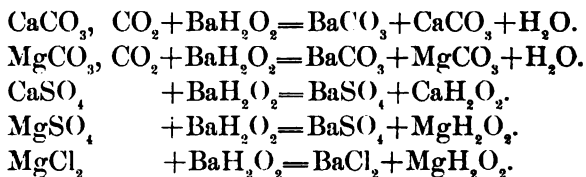


The practical difficulty with this reaction is that, in the cold, sulphate of barium deposits very slowly, and furthermore, when a water contains MgSO_4 , the reaction is



and this latter salt is objectionable in boilers on account of its corrosive action.

Hydrate of Barium is a more promising water purifier. It precipitates both the bicarbonates and the sulphates of lime and magnesia, but it has no action on CaCl_2 , if that salt is present. Reacting with MgCl_2 , it forms magnesium hydrate and barium chloride.



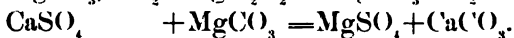
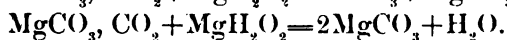
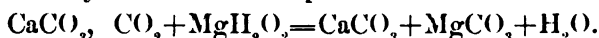
It would be possible to utilize the hydrates formed by the latter reactions for the precipitation of a portion or all the bicarbonates present in the water.

The use of barium hydrate is open to the objection that its price is quite high, and on account of its high molecular

weight, it requires a proportionately large quantity to accomplish the reactions.

The commercial barium hydrate contains 8 molecules of water of crystallization.

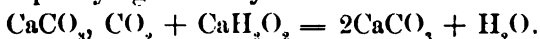
Bohlig and Heyne inaugurated in Germany the use of magnesium hydrate as a water purifier.



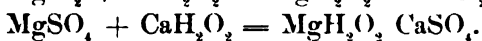
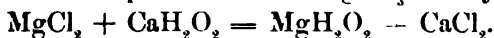
It was found necessary to treat waters by this process at 80°C. in order that bicarbonate of magnesium should decompose into hydrate. The procedure is therefore very costly and the purification incomplete.

Alkali Oxalates.—The lime salts are all precipitated by oxalate of sodium. As a by-product of the reaction of sodium oxalate on the bicarbonate of lime, there results carbonate of soda, and this, if formed in sufficient amount, will theoretically precipitate the magnesia which the water contains. As a matter of fact, when used in the cold, sodium oxalate produces a precipitate which settles very slowly, and although the deposition is more rapid when the solution is heated, it is still necessary to filter in order to obtain a clear water. Sodium oxalate being expensive, the process is costly, and although it is possible to regenerate by heating the precipitated oxalate of lime with sodium carbonate, this method has not found general favor.

Lime.—In 1840, Dr. Clark, of Aberdeen, patented his process for purifying water by the addition of lime.



This process is especially useful for waters containing only carbonate of lime, sulphate of lime is not acted on by CaH_2O_2 . Bicarbonate of magnesium is precipitated by CaH_2O_2 , but the deposition of the MgCO_3 is very slow.



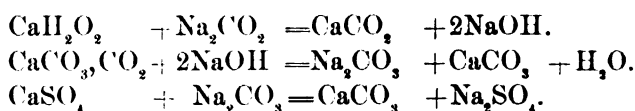
The last reaction has a very objectionable by-product, CaSO_4 .

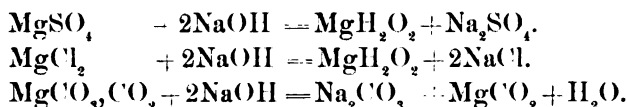
It is not possible to lower the CaCO_3 below 3.6 parts per 100,000, the solubility of CaCO_3 in pure water, and as a matter of fact, the result of the Clark process is usually not so good as this. At Bushey, in Herts, near London, the Clark process is used for purifying the town supply and the purified water has a hardness of 5 to 6 degrees, corresponding to 7 to 8.5 parts per 100,000.

The following experiment by Fischer shows the rate of settling of the CaCO_3 after the theoretical amount of lime has been added. In one hour, one liter contained 320 mgs. of CaCO_3 , in 2 hours 220, in 12 hours 80, and in 22 hours the quantity had not further diminished. Precipitated at 47°C ., one liter contained only 80 mgs. after about a quarter of an hour. Precipitated at 60°C ., all but 50 mgs. separated in one-fourth of an hour, while at 70°C . only 40 mgs. remained. To test the effect of agitation in promoting the separation of CaCO_3 , two parallel experiments were made, in which the theoretical amount of lime water was added to each of two solutions containing bicarbonate of lime, and one flask and its contents vigorously shaken for 11 minutes, while the other remained quietly standing. The one which was shaken contained only 46 mgs. CaCO_3 in solution, while the other contained 300 mgs. It is thus seen that shaking effects as rapid a precipitation as does warming to 60°C .

Lime and Soda Ash.—These two substances are often used in conjunction, and they are capable, either by themselves or in connection with the substances produced by their action on each other, of bringing about a nearly complete softening of any water intended for boiler use.

The reactions are :





It will be thus seen that the amounts of carbonate of soda and lime which are used are to be varied according to the proportions of bicarbonate or temporary hardness and the sulphates and chlorides of lime and magnesia which constitute permanent hardness.

The following rules have been formulated and are concisely given in "Water and Its Purification," S. Rideal, London, 1897.

Rule I. For a water in which the temporary hardness exceeds the permanent, caustic soda must be added equivalent to the permanent hardness, and lime equivalent to the temporary hardness minus the permanent hardness.

Rule II.—For a water in which the permanent hardness, due to sulphate of lime, exceeds the temporary hardness, carbonate of soda must first be added in proportion to the permanent hardness, and then, if necessary, lime equivalent to the temporary hardness.

My own experiments have indicated that the process is not available for waters which contain only moderate amounts of carbonate and sulphate of lime. For example, a water of the following composition was treated with a mixture of lime and soda ash in proportion slightly in excess of the theoretical requirements.

Composition of water :

CaCO_3	—6.43	parts	per	100,000.
MgCO_3	—0.85	"	"	"
CaSO_4	—0.97	"	"	"
MgSO_4	—0.29	"	"	"
MgCO_3	—0.59	"	"	"

As a result, although the soda was causticized before adding the water, no precipitation occurred immediately, except

that produced by the action of the carbonate of soda on the CaH_2O_2 . After several hours a thin film of CaCO_3 formed on the vessel, but there still remained in solution practically all of the lime originally in the water, together with that portion of the CaH_2O_2 not carbonated by the Na_2CO_3 . It is the author's experience that boiler waters containing considerable CaSO_4 are easier to precipitate than are those which contain chiefly CaCO_3 . The practical working of the lime and soda process will be considered further on.

Carbonate of Soda may be used as a reagent for purifying water for boiler use, but unless the water is quite rich in CaSO_4 no precipitation will take place in the cold. In the steam boiler, however, the soluble calcium and magnesium salts are transformed into carbonates which are non-adherent under ordinary boiler conditions. This process has proved its usefulness in railway work and elsewhere.

Caustic Soda.—(*NaOH*).—This substance is capable of effecting complete purification of a water provided it contains enough carbonic acid in carbonates to form with the caustic soda sufficient carbonate of soda to precipitate the sulphate of lime. The reactions involved have already been given.

Purification by caustic soda cannot be accomplished in the cold with waters of a moderate degree of hardness, as the following experiments show :

20 c.c. of a centi-normal solution of each of the hardening salts contained in water was diluted with 25 c.c. of distilled water and treated with the theoretical amount of caustic soda. With the exception of the solution of CaCO_3 no precipitation occurred, although the strength of solutions corresponded to over 20 parts per 100,000.

Sodium Phosphate.—This substance enters into reaction at once with all lime and magnesia compounds which occur in natural waters. The reaction is much less complete in the case of the magnesium salts and it is not absolutely complete in the cold in any case. The precipitate of phosphate of lime is

bulky ; $\frac{1}{4}$ gm. of CaO gave 100 c.c. of sludge. 1,000 gallons of water containing the equivalent of 7 parts CaO in 100,000 would produce 32.5 gallons of sludge.

Solutions of CaCO_3 , MgCO_3 , CaSO_4 , MgSO_4 , CaCl_2 and MgCl_2 containing 20 c.c. of c.n. solution of each in 45 c.c. of liquid, deported themselves as follows with 2 c.c. of decinormal sodium phosphate, the quantity theoretically required for their precipitation.

At the dilutions given above the solutions contained :

CaCO_3	—20.6	parts per 100,000.
MgCO_3	—17.8	“ “
CaSO_4	—29.0	“ “
MgSO_4	—25.6	“ “
CaCl_2	—23.6	“ “
MgCl_2	—20.6	“ “

TREATMENT WITH SODIUM PHOSPHATE.

CaCO_3 gave a flocculent precipitate at once. Removal in cold approximated 75 %.

MgCO_3 gave no precipitate whatever. No Mg. removed.

CaSO_4 gave flocculent precipitate at once. Removal in cold approximated 70 %.

MgSO_4 gave opalescence. Bare trace of flocculent precipitate over night.

CaCl_2 gave flocculent precipitate at once. 62 % precipitated in cold.

MgCl_2 gave opalescence. Bare trace of flocculent precipitate next morning.

PRECIPITATION OF LIME FROM NATURAL WATERS BY SODIUM PHOSPHATE.

A water containing 7.60 parts CaO per 100,000 (4.27 insoluble 3.20 soluble) gave, in the cold, with sodium phosphate (110 % of theoretical amount) a precipitation corresponding to 80 % of the lime present. The remainder came down on boiling.

A water containing 3.77 parts ins. lime and 1.47 sol. lime

gave a precipitate of 69 % of the lime in the cold and the remainder deposited once after short boiling.

PRECIPITATION BY SODIUM PHOSPHATE OF WEAK SOLUTIONS OF LIME AND MAGNESIA COMPOUNDS.

10 c.c. of c.n. solutions of CaCO_3 and CaSO_4 were diluted to 100 c.c. and 1 c.c. of deci-normal sodium phosphate added.

In neither case was there any apparent cloudiness at first, although the one solution contained 5 parts CaCO_3 and the other 6.8 parts of CaSO_4 in 100,000.

By adding twice the theoretical quantity of sodium phosphate, a flocculent precipitate appeared. The solution had become clear in 3 hours. In the case of the CaCO_3 solution, a heavy precipitate appeared on boiling, and in that of the CaSO_4 a lighter one. No weights were made.

These experiments indicate that in moderately hard waters, more than the theoretical quantity of sodium phosphate does not produce complete precipitation of the lime compounds.

With waters of 20 parts of lime salts per 100,000, a 75 % purification may be effected in the cold.

Sodium Fluoride.—The use of this substance as a boiler water purifier has been patented by Dr. C. A. Doremus. It is not adapted for use outside the boiler, because the fluorides of lime and magnesia do not precipitate well in the cold, as the following experiments show. The precipitation of CaF_2 by NaF from a 5 part per 100,000 solution of CaCO_3 even when boiled down to one-third volume was not even begun.

EXPERIMENTS WITH SODIUM FLUORIDE.

The amounts of sodium fluoride used were slightly in excess of the theoretical requirements:

Exp. 1.—10 c.c. c.n. CaCO_3 + 90 c.c. H_2O + 1 c.c. sodium fluoride solution. No precipitate in 24 hours. Added 1 c.c. d.n. Na_2CO_3 . No precipitate.

Exp. 2.—Same as No. 1, but used twice as much sodium fluoride as before. No precipitate. Boiled down to 30 c.c. No precipitate.

Exp. 3.—10 c.c. c.n. CaSO_4 + 90 c.c. H_2O + 1 c.c. NaF .
No precipitate in 24 hours, even with 1 c.c. d.n. Na_2CO_3 added.

Exp. 4.—10 c.c. c.n. CaSO_4 + 90 c.c. H_2O + 2 c.c. NaF .
No precipitate.

Experiments were made with stronger solutions of CaCO_3 , etc., as used in the case of the sodium phosphate experiments.

CaCO_3 —20.6 parts per 100,000 + NaF sufficient to precipitate. No precipitate in 48 hours.

CaSO_4 —29.0 parts per 100,000 + NaF sufficient to precipitate. Thin film in 48 hours.

MgCO_3 —17.8 parts per 100,000 + NaF sufficient to precipitate. No precipitation in 48 hours.

MgSO_4 —25.6 parts per 100,000 + NaF sufficient to precipitate. No precipitation.

CaCl_2 —23.6 parts per 100,000 + NaF sufficient to precipitate. No precipitation at first; slight precipitation in 24 hours.

MgCl_2 —20.2 parts per 100,000 + NaF sufficient to precipitate. No precipitation in 24 hours.

These experiments indicate the limitations of the use of sodium fluoride. Its use is further debarred by its cost, the lowest figures at present quoted being 14 cents per pound in barrel lots.

The advocates of the use of the fluoride claim that the reactions between it and the lime compounds in the boiler are instantaneous, and that the fluoride sludge thus formed is absolutely non-adherent. They claim that the use of $\frac{1}{4}$ of the theoretical amount of sodium fluoride produces a sludge which prevents other scale-forming substances from adhering, a proposition which cannot be received unquestioned. It is also stated that the use of sodium fluoride is an advantage in cases where the quality of the steam produced is injured if the water is alkaline. The use of fluoride would not affect the reaction of the water nor the quality of the steam.

COMPARISON OF WATER PURIFIERS.

ADAPTABILITY FOR SOFTENING OUTSIDE THE BOILER.

Lime.—For bicarbonates ; for soluble magnesia, if high; for acid waters of any degree of acidity.

Soda Ash.—For waters containing CaSO_4 or CaCl_2 or $\text{Ca}(\text{NO}_3)_2$ in large proportion. Ordinary waters unaffected by soda ash in the cold.

Caustic Soda.—For bicarbonates directly ; for magnesia salts, if present in extraordinary proportion ; for soluble lime if sufficient Na_2CO_3 is formed by the decomposition of the bicarbonates.

Tri-Sodium Phosphate.—For lime compounds. About 75 % is precipitated in the cold. Magnesium phosphate deposits with extreme slowness.

Sodium Fluoride.—Unsuited for precipitations of lime and magnesia outside the boiler.

SUMMARY.

Bicarbonate of lime and to a less extent bicarbonate of magnesia, may be precipitated outside the boiler by lime or soda or tri-sodium phosphate ; for sulphate of lime, and other soluble salts, if present in large proportion, use soda ash ; if in smaller amount, only tri-sodium phosphate is available. From water containing both bicarbonate and sulphate of lime, the use of lime and soda ash removes indirectly nearly all of the soluble lime compounds. For acid waters, lime may be used, but soda ash or caustic soda are the best neutralizing agents.

For magnesia compounds in ordinary waters, no practically successful means of precipitation in the cold is known. In connection with removal of lime by the use of lime and soda ash, a small amount of magnesia is precipitated.

SOFTENING OF WATER IN THE BOILER.

For Bicarbonates.—No precipitant is needed. Heat accomplishes the work.

For Soluble Magnesia Compounds.—No precipitant is

needed. They are decomposed under boiler conditions, the magnesia being deposited as hydrate. This deposition is hastened by the presence of soda ash or caustic soda, and any acid liberated by decomposition of magnesia salts is at once taken up and rendered harmless.

For Soluble Lime Salts.—Soda ash is cheap and effective. The sludge must, of course, be removed regularly. Sodium phosphate may be used. It forms light, bulky precipitates, whereas those formed by sodium carbonate are more dense. Sodium fluoride may be used, but the expense is two and a half times greater than that for soda ash, even when only $\frac{1}{4}$ of the required amount is used, as suggested by its advocates.

Furthermore, there is no means of preventing sodium phosphate and sodium fluoride, when added to a water containing both bicarbonates and sulphates from doing useless work by precipitating the bicarbonates, and leaving the sulphates undecomposed.

COMPARISON OF WATER PURIFIERS.

EQUIVALENCE AND COST.

	Mol. Wt.	Equiva- lence.	Ratio.	Price per lb.	Price per Unit of Lime Precipitated.
Lime.....	56	28	1.00	0.4 cts.	0.4 cts.
Soda Ash.....	106	53	1.89	1.06 "	2.0 "
Caustic Soda.....	40	40	1.43	2.69 "	3.85 "
Tri-Sodium Phos...	380	127	4.54	{ 4.0 " to	18.2 " to
Sodium Fluoride...	42	42	1.50	{ 5.0 " *14.00 "	22.7 " 21.0 "

*NOTE. This is the lowest price at which Fluoride Water Purifier (Com'l. Sodium fluoride) is sold by the manufacturers licensed by the patentee. Commercial sodium fluoride is quoted by Jas. Irwin and Co., of Pittsburg, at 8c per lb., in 200-lb. lots.

THE CLARK PROCESS FOR SOFTENING WATER.

The writer had an opportunity of seeing this process, as it is now used, at the Colne Valley Water Works, in England.

Aside from the pumping plant, the apparatus consists of two tanks for lime water, and a tank for measuring the quantity of water which is to be treated. The lime water is, from time to time, renewed, after the addition of fresh water, by blowing of air through an excess of lime which is maintained at the bottom of the tank. The clear lime water is drawn off through a floating discharge pipe. While one tank is being drawn from, the water in the other is being saturated with lime by the process above indicated. The mixture of lime water and hard water flows by gravity to settling tanks, where the precipitate subsides and the clear water is drawn off. At the works referred to, the chief drawback seems to be the difficulty of economically disposing of the precipitated carbonate of lime.

Rideal states that for a moderate sized town, requiring 250,000 gallons per day, each of the two lime water tanks should hold 40,000 and the three settling tanks 300,000 gallons each.

The objections to the Clark process are, first, the large plant required; second, heavy working expenses; third, incomplete precipitation.

THE PORTER-CLARK PROCESS.

This improvement on the Clark process consists, first, in an arrangement for automatically mixing the lime with the water. The mixture is then passed through filter presses, and a clear water at once obtained. At Camden town, the L. & N. W. Railway soften 7,000 gallons of water per hour continually, reducing it from 18° to 4° , maintaining a pressure of 60 pounds per inch. The lime is automatically churned in a horizontal cylinder, and is delivered by means of a water motor, actuated by the pressure of the water which is being purified. By this means, the supply of lime water is made proportional to the flow of hard water. A practical difficulty sometimes encountered in working this process is a clogging of the filters, which takes place unless the lime is kept in excess. It is also desirable to avoid more than a slight excess if mag-

nesia is present, as this separates but slowly under the influence of lime and also clogs the filters.

THE ATKINS-CLARK PROCESS.

At the Southampton Water Works, Atkins's process is used. This consists mainly of an improved method of filtering. The filtering medium consists of an endless band of cotton cloth, which travels slowly around a perforated horizontal revolving cylinder. The cylinder has a hollow axle, and is partly immersed in a cistern containing the water which is to be clarified. The water filters inward, leaving the precipitate on the outside of the filter cloth. Filtration is assisted by a partial vacuum in the cylinder or by a sufficient fall in the outlet pipe. The cloth passes on over rollers, and is rinsed, boiled and steamed before it returns. It is claimed that a machine of this type will soften 2,000 gallons of water per day, at a cost of one farthing per 1,000 gallons.

SODA ASH AS A WATER PURIFIER.

Of 27,600 boilers inspected in Germany in 1891, 5,480 were being fed with treated water. Of these, 3,800 were receiving sodium carbonate (or BaCl_2), with the feed water; 1,400 were being fed with purified water. ("On the Purification of Water Used for Steam Boilers," by R. Jones, Ph. D. z. ang. chem. 1892,—15; Abs. C.N. 1893—171 and 185.) A boiler fed with Elbe water at Hamburg was supplied for 13 weeks with water to which soda ash equivalent to an excess of .03 to 0.20 gm. per liter had been added. The soda ash was added to the water in a small steam boiler used as a heater. The solution then passed through filter presses to the boiler.

The improvement effected was as follows :

	Raw.	Treated.
Lime (parts per 100,000).....	4.7	1.1
Magnesia " " ".....	1.3	1.0

The water in the boiler was blown down from the upper to the lower gage every day. After 13 weeks' run the boiler surfaces were practically clean.

The following notes have been communicated to the writer by those who have derived practical benefit from the use of soda ash in boilers.

FIRTH STERLING STEEL COMPANY.

This company uses Monongahela river water below McKeesport. They use soda ash to neutralize acid, and find that it also prevents hard scale formation. They do not use enough soda ash to decompose all the sulphate of lime, and hence get some scale.

"We use soda ash alone. * * * The results of this treatment are very satisfactory. *The boilers are never attacked and the scale is very easily removed.*"

CHICAGO, MILWAUKEE AND ST. PAUL RAILWAY.

"Our practice in water purification is still confined to the use of soda ash in our locomotive boilers. A few years ago we made extended experiments with tri-sodium phosphate, using it on all our Chicago-Milwaukee division engines for about a year. The result was that an article of 90% purity was $\frac{1}{3}$ to $\frac{1}{2}$ more efficient than an equal weight of soda ash of 58%. But the cost of the phosphate was, and still is, too high to enable it to compete with ash. It appears to have a slight advantage over ash in that the sludge does not so easily produce foaming. The difference in this respect is not very great, however. * * * There are usually a few small patches of very thin scale, say $\frac{1}{8}$ inch thick, which come and go, here and there, apparently flaking off before attaining injurious thickness. *The bulk of the surface is, however, perfectly black metal.*

"The only trouble which we have now is due to corrosion, which has occurred in a few places in a few high pressure boilers, *which have made some scale on account of insufficient soda ash.* The matter is not yet fully worked out, but will

probably be shown to be due to the action of already deposited calcium sulphate on the metal contiguous to it ! ”

In a circular for engineers on the C. M. and St. P. Ry., it is stated : “ By the addition of soda ash to water, all the incrusting solids may be thrown down, as a loose deposit of carbonates.”

CHICAGO AND NORTH WESTERN RAILWAY.

“ *For several years we have been treating our boiler waters with soda ash*, and think we have been fairly successful with it. * * * We have found it quite necessary, in order to obtain satisfactory results, to use blow-off cocks frequently, and in order to enable our engineers to do this, we have equipped our engines with pneumatic blow-off cocks, which can be operated from the locomotive cabs.”

CHICAGO, BURLINGTON AND QUINCY RAILWAY.

“ Concerning treatment of boiler water, our practice is to put soda ash into the tank of the engine befor starting out on on a trip. * * * We have air blow-off cocks on the engines to use in case the engine foams on the road, also to blow out some of the water at the end of the trip.”

BALTIMORE AND OHIO RAILWAY.

“ On the Chicago Division we use *soda ash* in our engines, and have been able to *reduce the amount of scale formed and get longer service out of our flues*. With the proper attention, I regard it as satisfactory.”

USE OF SODIUM PHOSPHATE AS A WATER PURIFIER.

The advocates of tri-sodium phosphate estimate as follows:

A boiler of 100 H. P. operated 24 hours daily on Lake Erie or Lake Michigan water for one month, would evaporate 240,000 gallons. From this amount of water, 300 lbs. of lime, etc., would separate. This quantity would suffice to form a coating of scale $\frac{1}{4}$ inch thick, increasing the fuel consumption $\frac{1}{8}$. (Rideal estimates 50 per cent increase in fuel for $\frac{1}{4}$ -inch scale.)

They estimate that \$2.00 worth of tri-sodium phosphate or 40 lbs. would have prevented scale formation during this time. This would have been equivalent to the use of two and two-thirds ounces of tri-sodium phosphate per 1000 gallons of water. This quantity of phosphate will only precipitate the lime in 1000 gallons of water containing 0.44 parts of lime (CaO) per 100,000, equivalent to 0.80 parts of carbonate of lime, or 1 part of sulphate of lime per gallon.

General directions issued for the use of Tri-Sodium Phosphate are as follows :

Estimate 4,000 gallons evaporation for each 10 hours run of a 100 H. P. boiler in fair condition.

USE IN BOILERS.

Dissolve in hot water and feed into boiler through suction.

To Remove Scale. Use about 3 lbs. per 10 hour day for a 75 H. P. boiler, and propotional amounts for other sizes.

To Prevent Incrustation. For waters like those of the great lakes, use 3 ounces per 1,000 gallons, evaporated. For inland waters of usual hardness, 5 ounces per 1,000 gallons will suffice.

To Remove Grease. Use one to five pounds daily, and blow from the surface. For boilers without surface blow-off, use daily and blow frequently, or use from 10 to 50 lbs. at one application, boil about six hours, blow off and wash out.

PURIFICATION OUTSIDE OF THE BOILER.

Dissolve the proper quantity according to hardness of water being treated, and place in tank before the water is allowed to flow in. The water should rest one hour if hot, and about three hours if cold, to allow the impurities to settle. Clear soft water can then be drawn off for use.

To Neutralize Acid and Prevent Corrosion to Metals. Use from $\frac{1}{4}$ to $\frac{1}{2}$ pound per 1,000 gallons, according to acidity.

The limitations of the Sodium Phosphate method of water purification, have been already discussed in this paper. It is

the most generally applicable of all the chemicals used for water purification, but it is not cheap enough to replace lime and soda ash.

USE OF SODIUM FLUORIDE AS A WATER PURIFIER.

Sodium Fluoride is never used for the softening of water outside the boiler. It is always dissolved in water in a barrel or small tank, and fed through the pumps with the feed water into the boilers. The practical experience of those who have used the material has been that the formation of new scale was prevented, while the old scale softened or cracked off. It has been used to a limited extent in locomotives, but chiefly in stationary boilers.

The amount of sodium fluoride recommended for general use is 3 to 4 ounces per 1,000 gallons of water. One-fourth of the theoretical amount of fluoride required for precipitating lime or magnesia is said to prevent the adherence of the remainder of the scale-forming solids to the boiler sheets and tubes.

Four ounces per 1,000 gallons is equivalent to the lime in a water containing 2.00 parts of CaO in 100,000.

The objection to sodium fluoride is its expense and the slowness of the purification, even at a boiling temperature.

It is on a par with the tri-sodium phosphate in the matter of expense, and is inferior to it in speed of reaction.

PROCESSES IN WHICH LIME AND SODA ASH ARE USED.

These practically include, also, the ones in which caustic soda is the purifying agent. It is cheaper to prepare the caustic soda from lime and soda ash when needed. The theoretical considerations which determine the amounts of soda ash and lime to be used have already been outlined. The general method of industrial use is not patented, but certain appliances used in expediting and increasing the efficiency of the process are thus protected. Notable among these is the Archbutt-Deeley process, described in *The Engineering News* of December 22, 1898—(Softening of Water by the Archbutt-

Deeley Process, by Leonard Archbutt: a paper read before the Institution of Mechanical Engineers).

This process is carried out by means of the following arrangement of apparatus:

1. Tanks for dissolving the chemicals.
2. Precipitating and settling tanks.
3. Blower, actuated by steam.
4. Coke stoves, furnishing carbon di-oxide.
5. Floating discharge and carbonating arrangements.

The lime is slaked in hot water, and the soda ash dissolved in the mixture and boiled, by a steam coil, to causticize. The chemical solution is then forced down nearly to the bottom of the tank, where it is liberated through perforations in horizontal iron pipes. The sludge on the bottom of the tank is then stirred up well by the blower, and the precipitates allowed to settle. In about three-fourths of an hour the practically clear water can be drawn off. The water is carbonated as it is drawn off. The excess of sludge is removed from time to time.

For treating amounts from 4,000 to 10,000 gallons, per hour, two tanks are necessary, each tank having a capacity equal to two-thirds of the amount required hourly. The working depth of each tank is only three-fourths of its total depth, on account of sludge, which is purposely allowed to remain.

ANALYSES OF WATER BEFORE AND AFTER TREATMENT BY VARIOUS PROCESSES.

The Clark Process.

Parts per 100,000.

	Temporary Hardness.	Permanent Hardness.
Wellenborough.	43.29	23.14
Treated water.	1.57	21.29
Southampton.	32.86	3.86
Treated water.	8.00	4.29
New River Co.	27.29	5.14
Treated water.	2.71	4.86

The Soda Ash Process.

Soluble Lime.

Raw Water. Treated Water.

Water.

A.	3.20	.08
B.	3.33	.08
C.	1.47	.12
D.	1.95	.36

After 10 days use the water in the boilers of locomotives using the above supplies contained, before the use of soda ash, 20 to 30 parts of soluble lime per 100,000. After the introduction of soda ash, into the supply tanks, the water taken from the boilers contained only 1.6 to 2. parts of soluble lime per 100,000.

The Lime and Soda Ash Process.

Parts per 100,000.

Temporary Hardness. Permanent Hardness.

Well in London.	28.29	11.43
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Treated water.	3.43	8.57
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 CaCO_3 MgCO_3 CaSO_4 MgSO_4 Na_2SO_4 MgH_2O_2

Midland R'y.

Derby Works.

Archbutt-Deeley

Process	14.14	1.11	4.37	4.13
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Treated water.	3.76		0.24	2.39
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So. Pacific Ry.

H. Stillman.

Eng. News, Dec.

2, 1897.	24.47	2.09	5.26	29.37	6.09
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Treated water.	1.18	12.24	.49	2.79	47.81
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Analyses which show the degree of purification effected by sodium phosphate and sodium fluoride are wanting.

COST OF WATER SOFTENING.

Figures showing cost of water softening are of value only in a general way. The quantity and quality of the water

treated are determining factors, as well as the cost of chemicals and labor at the place of treatment.

The Clark process using lime is said to cost at Southampton .42c per 1,000 U. S. gallons.

Archbutt estimates that with soda ash at \$24.20 per ton and lime at \$4.84 per ton, purification by the use of lime of a water containing 20° of temporary hardness (20 grains CaCO_3 per Imp. gallon = 28.5 parts per 100,000) would cost 1.2c per 1,000 U. S. gallons.

For a 20° water containing half its hardness in the temporary form, softening would cost 2.6 cts. per 1,000 gallons.

If all the hardness were permanent, it would cost 4 cts. per 1,000 gallons. The fixed charges for labor, interest, etc., are estimated to be the same in all cases, viz.: .83 cts. per 1,000 gallons.

The purification of water on the Southern Pacific Railway costs 4 cts. per 1,000 gallons.

The Archbutt Deeley process at Derby costs 2 cts. per 1,000 gallons. The water is softened by lime and soda from 15° to 5°.

At Ashby, where lime alone is used, 45,000 gallons are softened hourly from 22° to 8.5° at a cost of 1.6 cts. per 1,000 gallons.

After discussion of the paper, ballots were distributed and the following officers unanimously elected:

Chairman, Dr. E. S. Johnson.

Vice " Dr. Walther Riddle.

Directors, J. O. Handy, W. E. Garrigues.

Secretary, A. G. McKenna.

The Annual Meeting adjourned at 10:20 P. M.

A. G. McKENNA,
Secretary C. S.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The one hundred and ninety - second regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the Society's House, 410 Penn Avenue, Pittsburg, Pa., Tuesday evening, February 21st, 1899.

The meeting was called to order by the President, Mr. Harry J. Lewis, at 8:20 P. M., forty-five members and visitors being present.

The minutes of the preceding meeting were read. Mr. Ralph Crooker, Jr., took exception to the statement in the minutes, with reference to the Committee on Smoke. After some discussion, and an amendment by striking out the name of Mr. Wilkins as reporting on behalf of the Committee on the Naval Bill, the minutes were approved.

For the Board of Directors, the following applicants were reported as passed and to be voted for at the next regular meeting :

JAMES BONAR,	- - -	Manager of James Bonar & Co., 1216 Carnegie Bldg., Pittsburg, Pa.
JOSEPH FAWELL,	- - -	Chief M. E. for Mackintosh, Hemphill & Co., Pittsburg, Pa.
MICHAEL GREENWOOD,	-	Agent for Laidlaw, Dunn, Gordon Co., of Cincinnati, Ohio. Carnegie Building, Pittsburg, Pa.
ARTHUR HERSCHMANN,	-	Representing Wm. Sellers & Co., Philadelphia, Pa. 1219 Park Bldg., Pittsburg, Pa.
REES JAMES,	- - -	Supt. Open Hearth Department. The Carnegie Steel Co., Ltd., Homestead, Pa. Munhall, Pa.
I. WALTER JENKS,	-	Supt. La Belle Steel Works, Allegheny, Pa. 139 Locust Street, Allegheny, Pa.

JOHN W. PARKER,	-	Chief Inspector Carnegie Steel Co., Ltd., Homestead Steel Works, 843 Linden Ave., Pittsburgh, Pa.
HENRY B. PRATHER,	-	Mgr. Buffalo Forge Co., for Pittsburgh, Ohio, West Virginia, Indiana and Kentucky. The Hollender, Cleveland, Ohio.
J. E. SCHLIEPER,	- -	Mgr. Pittsburg Feed Water Heater Co., 1216 Carnegie Bldg., Pittsburgh, Pa.
J. E. SCHWAB,	- -	General Supt. Duquesne Steel Works and Blast Fur- naces, Duquesne, Pa.
LOREN H. TURNER,	-	Supt. of Motive Power and Equipment of the P. & L. E. Railroad, 61 Maple Terrace, Pitts- burg, Pa.

The following gentlemen were ballotted for and duly elected to membership :

RALPH ALBREE,	- -	Partner of Chester B. Albree, 187 Western Ave., Allegheny, Pa.
D. HERBERT CHESTER,	-	Pittsburg Sales Manager, For Henry R. Worthington, 317 Third Ave., Pittsburgh, Pa.
LOUIS M. HARTWICK,	-	M. E. and Draughtsman, With Mackintosh, Hemphill & Co., 268 Fisk St., Pittsburgh, Pa.
WILLIAM J. KNOX,	-	Chemist, For George Westinghouse, 820 Penn Ave., Pittsburg, Pa.
JAMES P. LEAF,	- -	City Engineer, At Rochester, Freedom and Monica, Rochester, Beaver Co., Pa.
B. E. V. LUTY,	- -	Editor of <i>Tin and Terne</i> , and Mgr. of Pitts- burg Office of <i>Iron Trade Review</i> , 53 Ninth St., Pittsburgh, Pa.
CHARLES S. PRICE,	-	Acting Gen. Supt., Allegheny Valley Railway, 11th and Pike Sts., Pittsburgh, Pa.
W. E. SNYDER,	- -	Mechanical Engineer, With Schoenberger Steel Co., Penn Ave. and 15th St., 287 North Ave., Allegheny, Pa.

For the Committee on "Abatement of Smoke Nuisance," Prof. Fessenden stated that the Committee held one meeting, at which all the members were present, but no business was done, except it was moved that the Committee on Smoke

should co-operate with the Chamber of Commerce Committee until further developments.

At a general meeting of the Smoke Committee a sub-committee was appointed to lay out a plan of action and report to us. No further action has been taken as yet.

After some discussion, Mr. Wilkins moved that the Committee on the Abatement of Smoke Nuisance be discharged with thanks.

After some discussion, the motion was put and lost.

MR. JOHNSON—I believe the newly-elected President is expected to make some remarks that were omitted to-night.

MR. LEWIS—These remarks will not be as lengthy as an after-dinner speech. I have only to say at this time, gentlemen, that I deeply appreciate the honor you have placed in my hands. The approbation of a man's professional brethren is the hardest of all to win, and I want you all to understand that I greatly appreciate it. (Applause.)

Mr. Wilkins then moved that the Committee on Smoke be instructed to act independently of the Chamber of Commerce Committee and investigate the question of smoke and report to the Society.

The question was put and the motion carried.

For the Reception Committee, Mr. C. G. Schade read the following report :

REPORT OF TREASURER OF THE BANQUET COMMITTEE.

RECEIPTS.

168 Tickets sold at \$4.00 each.....\$672 00

EXPENSES.

Supper, 165 plates at \$3.00 each.....	\$495 00	
Cigars.....	27 00	
Music.....	30 00	
Flowers.....	30 00	
Printing.....	64 00	
Incidentals.....	12 65	
Total Expenses.....	658 65	658 65
Amount on hand.....		13 35

Yours very truly,

WILLIAM BRADFORD.

Moved that the Report of the Committee be accepted, and that the thanks of the Society be voted the Committee.

Motion carried.

Mr. Engstrom moved that the surplus remaining over with Reception Committee should go to the next Smoker, which was voted.

The paper of the evening, entitled "The Mining of Iron Ore," by Dr. Nelson P. Hulst, General Manager of the Oliver Iron and Mining Co., Milwaukee, Wisconsin, was then read. Dr. Hulst not being present, Prof. Fessenden read the paper.

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METHODS OF MINING IRON ORE IN THE LAKE SUPERIOR REGION.

BY DR. NELSON. P. HULST,

Gen'l Manager of the Oliver Iron and Mining Company, Milwaukee, Wis.

The iron ores of this region are mined in the States of Michigan, Wisconsin and Minnesota. There are six mining districts in the region, generally called ranges. They have that name from the fact that very generally the ore bodies occur in or along chains of hills. In general, the trend of these different ranges does not vary much from an East-West course. Each range furnishes ore peculiar to itself, and different portions of the same range have their characteristic ores. Any person well acquainted with the several ranges could, by an inspection of stockpiles of their ore in any distant place, quite unerringly name the mines whence many of the ores were obtained. Naming the ranges in the order of their birth, *i. e.*, their commercial birth, they are the Marquette and Menominee, of Michigan; the Gogebic, of Wisconsin and Michigan, and the Vermillion and Missabe, of Minnesota. The Marquette Range began producing ore in 1846 on a very limited scale. For the interval up to 1855 it is credited with an output of about 30,000 tons, all of which was consumed in the local forges of the district. In that early period of its history, only the rich, hard ores were considered worth min-

ing. The soft, hematite ores of the district were known, but they were entirely neglected until about 1870. In that year the soft ores near Negaunee were somewhat developed, but in a very small way as compared with the hard ore mines of the district. Out of a total output of 860,000 tons in 1870, considerably less than 1% was soft ores. All the early mines of the Marquette range were opened on outcrops of the hard, high-grade ores. They began as quarries, and with good judgment, since open pit mining, under certain conditions, is by far the most economical. Altogether the most satisfactory account of the early mining on the Marquette Range, is found in Chapter IX. of Vol. 1 of the Geological Survey of Michigan. This article, written by Maj. T. B. Brooks, the State Geologist at the time, is entitled "Method and cost of Mining Magnetic and Specular Ores." It was written about 1870. It represents the condition of the mining art on the Marquette Range at that time. It is probable that there had been but little advance over the methods in use when the range was first opened up in 1846. The Major states :

"The iron ores of the Marquette region are mostly
"extracted in open excavation. Several attempts have
"been made at underground work, which have not, on
"the whole, been successful. The Edwards Mine, opened
"in 1866, has been almost entirely wrought by candle-
"light. One pit of the new England mine was thus
"wrought in 1866, and at about the same time the
"Pioneer Pit, of the Jackson Mine, was in part worked
"underground. The Champion Mine, in 1868, was opened
"systematically as an underground mine. In 1870 this
"underground mining at the Champion was practically
"abandoned, and the greater part of the ore at that time
"was taken out from open pits. The Cleveland Mine
"about this time began to mine considerable ore under-
"ground. Several other mines, up to that time, had
"worked underground stopes, but only temporarily. If
"such stopes could not be opened out to daylight, they
"were usually abandoned. In brief, it may be said tha

“no considerable amount of ore had, up to 1870, been
“extracted from underground on the Marquette Range,
“and of that so mined, very little had been taken out at
“a profit.”

The Major gives as a reason for the unprofitableness of underground mining “the great width of the ore bodies, often 50 feet, making ordinary timbering difficult, if not practically impossible. The changing dip of the hanging from horizontal to vertical, sometimes occurring, interrupted any systematic plan of mining the ore.”

Thus quarry-work, started in the infancy of mining in this district, was clung to because of its simplicity. It was “convenient and economical to back a cart directly to the miners’ hands, and this was done until it came to be regarded as *the way* to get out ore.”

The shallow ore quarries of the early day had gradually become deeper, and by 1870 some of them were more than 100 feet deep. The necessary roadways for horses and carts or sleighs were cut out, at great expense, from the precipitous walls around which they circled. Sometimes the grades were 10%, and the cost of thus handling the ore, from the working-faces at that depth to the surface, was from 25c to 30c per ton. Up to 1870 and somewhat later, hand drilling was almost universal. Burleigh power drills were given a trial about this time in some of the mines. Their great weight made them unwieldy. This, with lack of skill to operate them, soon barred them from use. The Rand drill, lighter in weight and of better mechanical construction, soon followed and rapidly gained favor.

In 1869 high explosives were first used in the district. Nitro-glycerine at that time cost one dollar and a half per pound. Its economy as an explosive was due in a measure to the fact that the ore broken by it was thrown down in smaller fragments. Expensive block-holding was in a measure thereby avoided. Further economy came by its use in wet holes, which

grew more frequent as the open pits gained in depth. Compared with black powder in short holes, three to six feet deep, the nitro-glycerine was more effective by breaking a greater tonnage, which compensated the greater cost of it. Black powder, at the same time, cost from \$3.75 to \$4.50 per keg of 25 pounds. Drill Steel cost then 20c. per pound. With open pit mining heavy blasts from high stopes were permitted. Drill holes sometimes 22 feet deep were sunk in the stopes. Sand blasts were used to crack these deep holes at the bottom, until a space was secured for a heavy charge of black powder, of 25 to 30 kegs. Occasionally 5,000 tons of ore were thus thrown down. The slow burning black powder in such cases broke down the stope in large masses, which required repeated block-hole charges to break them to sizes required for handling.

As the work of quarrying the ore gradually deepened the pits, they reached depths after a while which prevented the use of roadways and carts. Swing derricks were then substituted and horse whims were used to operate them. In some cases steam engine hoists were used to operate the derricks.

Hoists had been recently installed, i. e. about 1870, for lifting skips through shafts, and Cornish pumps were the usual means of raising water when buckets were not used for bailing it.

At this time not much more than half the ore product of the district was handled by steam, (if the rock handled be included, far less than half was moved by steam) the balance was handled by horses and carts. Major Brooks comments severely on this large use of the expensive horse and cart method of handling ore, and prophesies "that if there ever comes a period when our mines do not pay, it may be due largely to horses," and he complainingly asks,

"In this age of steam, has a business any just right
"to prosper which employs horses to do work that
"can be more cheaply done by machinery?"

The manual labor of the mines was almost entirely done

on contract. The contractors received from 60c. to \$1.60 per ton of ore, with sometimes an allowance for rock. When the ore was exceptionally hard, requiring also blockholing and re-blasting, the cost for explosives reached 50c. per ton. The average cost of producing hard ore in the Marquette district in 1870 was estimated by Major Brooks on the best data he could obtain, to be per ton, \$2.64

To this he adds royalty,50

Commission, interest, exchange, insurance and
expenses of general office, - - - - .36

\$3.50

The mine owners and mine superintendents of 1870 suffered much anxiety as they saw their mines getting deeper, more difficult and more expensive to operate. The unsolved problem of getting ore economically by underground work was forcing itself into consideration as a necessity of the near future. Major Brooks evidently voiced the feeling that was then abroad when in 1870 he wrote,—

“The transition from the present system of quarrying to the future method of underground mining which will have to be made in this region, will be a critical period and will present great interest as affording a solution of a mining problem, such as may not have yet have been presented anywhere. Attempts at its solution have already been made, but as has been remarked, very little ore has been extracted at a profit underground. Now when we consider that the dressed ore is expected to yield 65%, in the furnace and is not worth at this time, 1870, on the average over \$4.00 or \$5.00 per gross ton on cars at the mine including royalty, the general character of the problem will be understood.”

It was at this period that a new order of things was beginning for the region. Bessemer steel manufacture had been recently established in our country and the metal supply for it required the best ores of this region. The iron industry was

also being rapidly expanded, especially in Western Pennsylvania, Ohio and at points on the Great Lakes, by reason of the improved transportation facilities connecting them with the new mines of Lake Superior. In consequence the ore production of this region bounded up from 297,000 tons in 1866 to almost 900,000 tons in 1870, an increase of 300%. This greatly enlarged output came for the most part from the old first opened mines of the district. Of necessity, the increased demands for ore from them brought an end to quarry and horse and cart work in their deepest pits. Steam engines for the work began to be installed and we find in 1870 a dozen engines in operation, none of which, however, were larger than 50 horse power.

Fortunately for the transition from open pit to underground mining, the selling price of ores at the time was exceptionally high. Having greater value, the costly experience of winning them was less of a burden to the producer. Shafts were sunk on the underlay and quite invariably in the ore body. This necessitated pillars of ore being left as a protection to them. The usual distance between shafts was from 200 to 250 feet. Levels were made 60 feet apart. Underhand stoping was the prevailing method. The width of the ore bodies was considered a bar to any different method. The ore was hoisted in ships and rarely in balance. One and a half to two tons of ore was a skip load. When possible the skips dumped directly into pockets whence the ore was loaded into railroad cars or else they dumped into surface tram cars which were quite invariably pushed by hand over a trestle to the stock pile grounds.

The high selling price of ores, together with the annually increasing demand, greatly stimulated their production. The percentage of increase was greatest with the soft ores of the region. As was noticed in the earlier part of this article, the production of soft ore in 1870 constituted less than 1% of the product of the region for that year. In 1880 the product

of the soft ores of the Lake Superior region was almost 45 % of the total output. The rapid development of the soft ore mines, which by their continually increasing product have constantly glutted the market, has been the factor most potent of all to bring about the gradual decrease in ore prices. As a consequence greater skill in mining and producing the hard ores has become necessary in order to meet the falling values.

Economy in producing them has come in many directions. Larger tonnage per shaft and fewer shafts now are noticeable. Shafts are located very generally in foot wall rocks. Thus placed they require the least amount of repairs and a tying up of ore in pillars for their protection is avoided. High grade engines for hoisting, pumping and air compression have been installed at most of the hard ore mines and hoisting in balance is generally in use. At some of the mines four and five tons of ore are hoisted to a skip load. Larger use of power drills is made, and in very hard ores, as at the Soudan mines on the Vermillion Range, the diamond drill is used for drilling in stopes by reason of its economy over percussion power drills for that purpose. The drilling cost by diamond drill is actually greater, but greater tonnage for the same drilling is broken by their use. Tramming by power is found in a number of the mines. In order to avoid delays in loading skips at levels, pockets for ore connecting with the shaft are arranged on different levels. Everywhere at these mines studied efforts have been made and are being made to reduce the amount of manual labor to the smallest minimum, since labor is one of the largest items in the cost of mining.

Fewer modifications from early practice have been made in methods of hard ore mining than in methods of soft ore mining, since in the latter more or less timbering is required.

It would be impossible, within the limits of this paper, to describe the mining methods of all the different mines of the several Ranges. Choice has been made of describing the method pursued at the Soudan hard ore mines of the Minne-

sota Iron Company, as representing a sharp breaking away from the usual Lake Superior practice in the mining of hard ores. The magnitude of the soft ore mines on all the Ranges (we include with them the Chandler and Pioneer mines, although their ores are in reality brecciated hard ores) has enlisted and tested the mining skill of many. For nearly a score of years there has been much experimenting on methods along different lines to work out some economical and safe plan of mining soft ores, and for each of the Ranges methods have been settled on as best meeting the varying conditions found to exist in different ore bodies.

It may be explained here that more descriptions are given of methods of mining soft ores than are given of methods of mining hard ores because of more varying conditions attaching to them and because the soft ores have now grown to be the chief part of the Lake Superior ore product, constituting in 1898 more than 80 % of it.

The method of mining hard ore at the Soudan Mine, on the Vermillion Range, has been well worked out. I am indebted for items in the description here given and for the drawings to a paper by D. H. Bacon, the President and Manager of the Minnesota Iron Company. This was published in Volume XXI. of the Transactions of American Institute of Mining Engineers. The Soudan ore bodies have sometimes had a width of eighty feet and varying lengths of several hundred feet. They lie as lenticular masses enclosed between locally-called greenstone rocks constituting the walls. They dip at a steep angle. Often the walls are friable and quite frequently treacherous. In the early mining, the ore was quarried from open pits to the depth of one hundred feet or more. For greater depth it became necessary to resort to underground mining. Shafts are located in the foot wall, as shown in Fig. 1, Plate No. 1. At intervals of 75 feet, crosscuts are driven into and across the ore body, as shown on this Plate. From each of these crosscuts, a chamber is mined out, 20 feet high in the

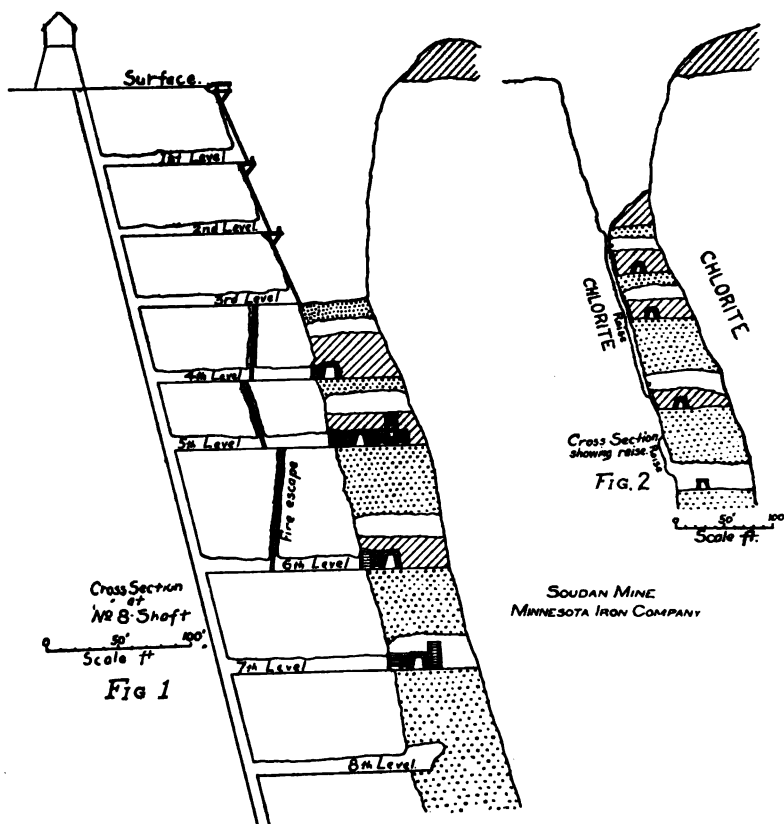


PLATE 1.

ore. These chambers to the several crosscuts are shown in elevation on Plate 1. They are shown in plan on Fig. 2, Plate 2; their longitudinal elevation is also shown on this Plate, in Fig. 1. The chamber of a level is made to extend on either side of the crosscut as far as the character of the walls of green stone, or chloritic rock, will permit. From the mouth of the crosscut, where it opens into an excavated chamber, the timber-work for a crosscut is extended well into the excavated chamber. This timber-work is well shown in elevation in Fig. 1, Plate 1, and in plan in Fig. 2, Plate 2. The timber-work for longi-

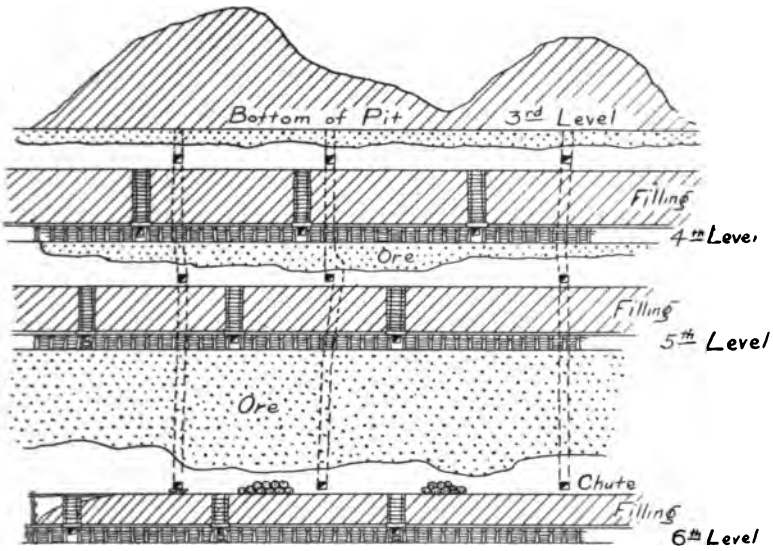


Fig. 1.

Longitudinal Section

0 50' Scale.

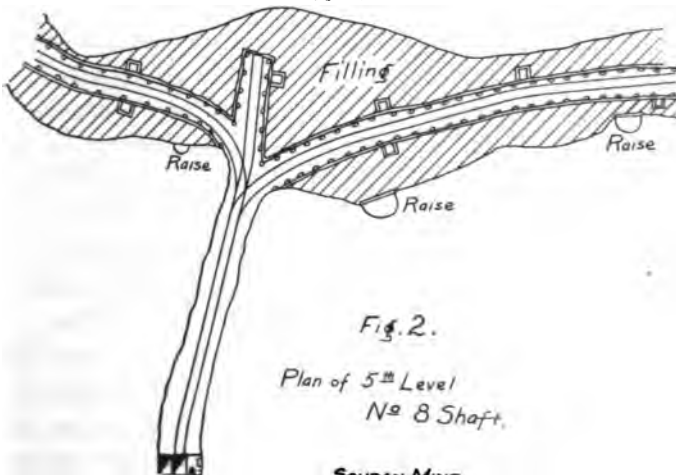


Fig. 2.

Plan of 5th Level
No 8 Shaft.

SOUDAN MINE
MINNESOTA IRON COMPANY

PLATE 2.

tudinal drifts is erected in these excavated chambers. As shown in plan on Fig. 2, Plate 2, they extend from the timbered crosscuts right and left. The timber-work of raises is also erected alongside of the drift timbering just described. These are seen in plan in Fig. 2, Plate 2, and in elevation on seventh level in Fig. 1, Plate 1. The timbered raises extend two to five feet above the timber-work of the drifts they are connected with. Other timbered raises are erected for ladder-ways. Still other raises are made to connect with the mine workings. These raises are in the wall rocks, either foot or hanging, according to requirements. These raises in the wall rocks are used for rock chutes. Through them rock from the open pit, near the surface, is brought down to any level required. These rock chutes are seen in plan in Fig. 2, Plate 2, and in elevation in Fig. 2, Plate 1. After the timber-work of crosscut, drifts and raises, in an excavated chamber have been completed, then rock from the open pit above is run down through the rock chutes and filled around and over the timber-work just mentioned, covering the drifts and crosscuts to the depth of three or four feet. The excavated chamber is further extended right and left by stoping away 20 feet of ore above the level, from wall to wall. The timber-work of drifts is extended. The necessary timber-work of raises for the lengthened drifts is completed. Stopping upward, *i. e.*, back stoping, is begun above the filling by blasting down 10 feet or more of ore from above and from wall to wall and as far as the filling over the timbering extends. This is shown in the longitudinal section in Fig. 1, Plate 2. The ore broken down on the filling is passed down to tram cars on the level below by the chutes described. After all this broken ore has been removed through the chutes, the chutes are built up to a proper height and filling of rock is repeated as before. The stoping on the level is also repeated and timber-work of drifts and raises erected in the extended chamber. Stopping, removing broken ore through the chutes, timbering and rock filling succeed one another

until the level is nearly exhausted of ore. A roof of ore is of necessity left to support the rock-filling of the level above. In the upper levels, this roof of ore was successfully removed by back-stoping during winter, after the filling had become thoroughly frozen. At lower levels, where the frost could not well penetrate, this winter removal of ore could not be made. The roof was there left thick enough for drifts to be driven in it. It was first caved down on the filling of the level below and then won by drifting and cross-cutting, which was not difficult in the broken ore.



TIMBER SHAFT HOUSE, NOMI MINES, GOGEBIC RANGE.

Large ore pockets are contained in the substructure above large openings, through which railway pass for loading.

Several systems of mining have been practiced at the Chapin Mine on the Menominee Range. The Manager of this Mine has kindly favored me by having his engineer furnish me with the following which covers the various methods which have been used and which at present are in operation there.

The ore bodies of the Chapin Mine which are lenticular in form and vary from a few hundred to over two thousand feet in length, with a width of twenty to one hundred and forty feet, dip to the North at an angle of about seventy degrees from the horizontal and have a westerly pitch of about forty-five degrees. The foot wall is a chlorite schist, locally called "slates," about one hundred feet thick, which in turn has a hard jaspillite foot wall. Near the ore body the schist is very much decomposed and of an extremely soft and friable nature. As the Jaspillite is neared the schist grows stronger and harder, and gradually becomes more quartzose, until the line of demarkation between the two is indistinct.

The hanging wall is also a chloritic schist having much the same characteristics as the foot wall schist; i. e., near the ore it is soft, friable and broken up and of a very slippery nature. In the extreme ends of the lenses, where the ore is narrow and so hard that it is necessary to use machine drills to drive the drifts, the openings are subjected to excessive lateral pressure, due to the instability of the foot and hanging walls. The legs of the setts are buckled inward on both sides of the drift while the caps remain intact, showing that the pressure is a squeezing from both foot and hanging, rather than a vertical pressure due to the weight of the ore undercut. Openings in the ore do not show this peculiarity, indicating that the ore is more stable; in fact the ore is hard enough to require machine drills for all development work. We have then an ore body of a fairly stable nature and a foot and hanging of an extremely unstable character.

Although, in common with a majority of the larger mines on the Menominee Range, there is a large amount of water in the ore formation, the ore drains readily and the percentage of moisture is from 6% to 8%. It may be interesting to mention in this connection, that something over six tons of water are raised for each ton of ore raised at the Chapin Mine.

It was first attempted to extract the ore on stulls, but the

ore body soon became so wide that the room and pillar system was tried. This consisted of taking rooms twenty feet wide and from foot to hanging, leaving pillars eighteen feet wide. The rooms were not filled, but were timbered with square setts, such as are usually used in this style of mining. A photograph accompanying the paper shows the timber square setts of a room. The sudden caving in of several of these rooms, due to the unstable foot and hanging, and possibly also to the weight of sand and boulders lying on the ore, taught that this system was not practicable. Then the plan of filling the rooms with sand and with rock quarried for that purpose was tried. It was found there was a settling of the surface, and as many tracks, buildings, trestles, etc., etc., were located immediately over the ore it was desired these should remain undisturbed by any subsidence of the surface. After the rooms had been worked out and filled down to the sixth level, it was found the pillars were crushing and an attempt was made to remove them and still support the surface by the slicing and filling system. Figure 2 of Plate 3 is a plan showing foot wall level, chutes, crosscuts and longitudinal slices. The arrow points indicate the direction in which the openings were driven. Figure 3 of Plate 3 is a vertical cross section through two levels showing the foot wall levels, winze for running the filling down to the slices, crosscuts, chutes for running the ore down to the levels and another tier in process of being worked out and filled, and another tier in the process of being worked out. As shown, levels were driven in the foot wall, and opposite each pillar raises were put up high enough for a chute and crosscuts driven out to and through the ore to the hanging. From these crosscuts 7'x7' longitudinal slices were driven to the limits of the block of ground. As soon as the first slice on the hanging was completed, it was filled, the men were brought back and another slice started alongside the first. This method was pursued until the whole block of ground was undercut and filled. An

additional 7' was added to the height of the raise, the back of the original crosscut in the rock was stoped down and the rock thrown underfoot so the rock formed the floor of the new crosscut which was extended to the hanging and slices were driven and filled in the manner described above ; the filling in the last tier of slices forming the floor of the new crosscuts and slices. This process was continued until the lift was worked out. It was found there was still a settling of the surface, consequently all the attempts to sustain the same were abandoned and the tracks and buildings were moved.

The filling of the slices was abandoned and on the fourth, fifth and sixth levels the pillars were undercut in substantially the same manner described above, the timber, which was light, blasted out when necessary, and the pillar allowed to settle the distance of the height of the slice. This was called the "Settling System" and it worked satisfactorily in the ground just referred to which was soft and crushed, as many as seven slices being taken on the same rails, but upon attempting to apply it to ground on the seventh level, which was harder and had not been crushed, it was found the pillars broke up in large masses when undercut and allowed to settle. These masses were too large to handle without block holing and blasting and were so heavy the timber in the slices were broken too soon, which showed there was too much weight in the ground undercut. This led to the adoption of what is known as the "Caving System," which is essentially the same as the Settling System with the modification that the thickness of the back is decreased to suit the conditions obtaining. In the meantime, rooming and filling had been continued, and before the Caving System had been extended to all parts of the mine, the mine had been opened up on this system down to the eleventh level. Necessity of keeping up the production was the chief reason for doing this, which could only be done in this way as it took considerable time to demonstrate the feasibility of the caving system and to open

up the ground preparatory to its general adoption. In applying the caving system to the taking out of the pillars after the rooms are filled, the following method is pursued: See Fig. 6, Plate 3.

SLICING AND SUB-DRIFT CAVING SYSTEM.

CHAPIN MINE.

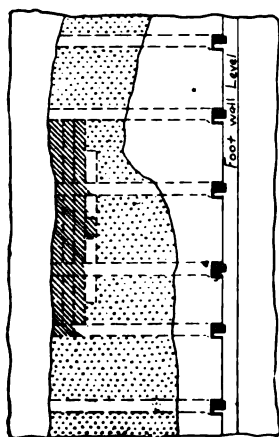


Fig. 2. Slicing System

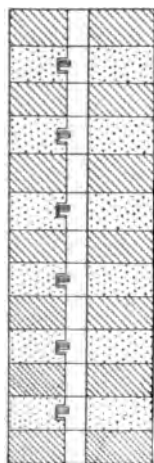


Fig. 4. Caving System. Plan showing filled rooms, pillars, raises, level, etc.

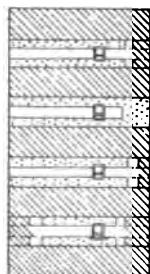


Fig. 5. Caving System Plan showing filled rooms. Cross cuts in pillars. Location of chutes. Longitudinal slices, etc.

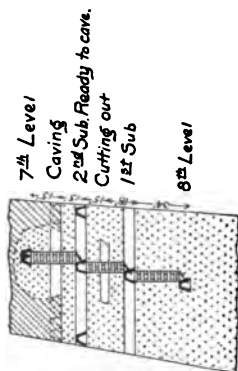


Fig. 6. Sub-drift caving system

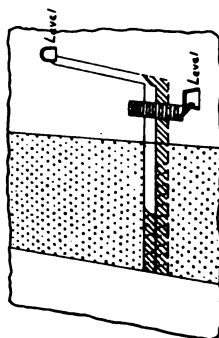


Fig. 3. Slicing System

The levels are driven about in the center of the ore, one hundred feet apart vertically. For the sake of illustration, suppose the ore has been taken out down to the seventh level and it is desired to mine the lift between the seventh and eighth levels. From the eighth level two compartment raises, five feet by seven feet, are put up to the seventh level. The seventh level is kept open as long as possible, chiefly to provide for getting timber down to the crosscuts, drifts and slices. It sometimes happens that all of the preceding level has to be abandoned and in that case the timber has to be pulled up from the level below by hand, which is a slow, laborious and expensive process. Consequently this is avoided as much as possible. The height of back that can be most advantageously handled under the conditions at the Chapin Mine, has been demonstrated to be about eight feet. After the raises are up to the seventh level, a crosscut, 7'x7', is driven fifteen feet below the level to both foot and hanging and timbered with light timber, locally called "slice setts." Top lagging only is used. When the foot is reached, the miners begin to take off successive longitudinal slices, timbering only enough to protect themselves from the back. The weight of the overlying debris crushed the back which soon begins to come down with the help of an occasional stick of dynamite, and the process of "robbing back" is in full operation. When the miners get within a couple of slices of the raise they begin slicing on the hanging side in the same manner, the slices nearest the raise being the last taken. In the meantime another party of men has been driving a crosscut immediately under and fifteen feet below the first. As soon as the first floor is caved, caving is begun on the second and so on down to the eighth level. It occasionally happens that two parties will be caving while a third is "cutting out," but as a general rule two gangs of two men each on each shift are all that are worked in a pillar. Any ore that fails to come down on any lift is obtained on the next. After the ground is cut out, all machine drills and air

pipes are removed and the miners put in their holes with hand drills and jumpers. When they have machine drills, they have a tendency to put in too deep holes and cave too much ground and thereby lose control of it.

There are no large openings, and the roof and sides of the working places are at all times close to the miners which permits of frequent, careful examinations both by the workmen and the bosses. The crushing of the ore by the weight of the debris lessens the amount of powder used and also the labor necessary to break the ore. From thirty to fifty per cent. of the ore mined is obtained without the use of powder.

The caving system, with the addition of sub-drifts, is also applied to ground which has not been roomed and which has a heavy capping of jaspillite. The method of working is essentially the same, with the advantage that there are no filled rooms on each side of the pillars.

The levels are one hundred feet apart vertically and connected every fifty feet by raises. These raises are in turn connected by sub-drifts, that is, intermediate drifts between the levels. The ground is then cut up into blocks by cross-cuts and drifts and caved in the same way the pillars were when blasted, and is run into the tram cars without being handled. The objects of these sub-drifts are to provide a means of exit for the miners in case of accident, "two ways out" being the rule; for ease of communication and for getting timber into the openings. In some parts of the old workings, where the rooms were not beat up too high, sub-drifts are made use of, but where there is filling to be driven through, they are driven only in exceptional cases. In places where the ore is wide, there may be two drifts: one near the foot and one near the hanging, with the necessary raises, so that there are two separate parties caving on the same block. Care is always taken that no caving is done until the party above is out of danger of having their ground caved under their feet.

A very successful method of mining ore by a system of caving has been devised by Mr. E. F. Brown, Manager of the Pewabic Mine. This mine is situated on the Menominee Range and lies within a short distance of the Chapin Mine. This method proves to be particularly well adapted to the conditions existing at the Pewabic Mine. It is described by Mr. Brown as follows :

The system of mining herein described has been in successful operation at the Pewabic Mine, Iron Mountain, Michigan, for a period of three years, and about 600,000 tons of iron ore have been extracted from the points in the mine where it has been found advantageous to make use of this method exclusively. This system has been employed most extensively upon a large body of highly silicious hard hematite ore, averaging from 40 % to 50 % in iron.

For convenience in operating, the ore body is first divided into blocks, having a length on the trend of the strata of about two hundred and fifty feet ; the width of the blocks depending upon the distance between the slate walls, or foot and hanging. The height of the blocks is the distance between levels, ordinarily one hundred feet. The accompanying Plates show one of these blocks of ore in various stages of preparation for actual mining ; also the condition of the over burden, consisting of broken sand-stone and old timber, which had been caved by earlier mining operations.

Plate No. 1 A shows the plan of crosscutting and raising, in blocking out the ore ; also the location of the ore with reference to the main levels.

The main level is driven in the hanging wall slates, about twenty feet from the ore body, and parallel with its trend. From the main level, crosscuts are extended across the ore body to the foot wall. We usually make four crosscuts, these dividing a block of ground two hundred fifty feet long into three blocks about eighty feet each. Adjacent to the two crosscuts which mark the eastern and western boundaries of

the original block, we start upraises fifty feet distant from each other, and extend these upraises eighty feet, or within twenty feet of the level immediately above.

Plates Nos. 4A and 5A are vertical sections taken through A-B and C-D on Plates 1A and shows the upraises in detail. Chutes are constructed at the bottom of the upraises, and commencing at the top underhand stoping is carried on until a trench eight feet wide and eighty feet deep has been cut across the ore body from foot to hanging wall.

In the underhand stoping the ore falls into the chutes when blasted and is run into the tram cars without being handled. During the time required to cut the trenches across the ends of the block, we are also employed in undercutting it, and when the trenches are completed, we have the bottom of the block about in the condition shown by plate No. 2A. That is, we have two strong pillars alongside of the main crosscut on the ends of the block, while the balance of the ground is resting on small legs of ore, irregular in size and shape.

These legs and pillars are then made as small as is consistent with safety to our miners. The remaining portion is then drilled, and when all have been drilled, they are blasted in sections. The end of the blocks being cut off, and the entire block thoroughly undercut, the ore soon begins to cave. This usually occurs in large masses of many hundreds tons each.

To illustrate the hardness of the ground and the results obtained, it may be well to state that no timber is used in prosecuting the work just outlined, and that it requires several weeks for a block of this ore to settle a distance of seven feet, but within six or eight months the ore becomes crushed so that four-fifths of the entire block could be put through a three-inch opening. After the block of ore has settled down to the original level, and been sufficiently crushed to allow easy driving of crosscuts, the two crosscuts in the central portion of the block are advanced through the caved ore, and

Plan showing Drifts and Cross cuts.
Through the Block after being Covered

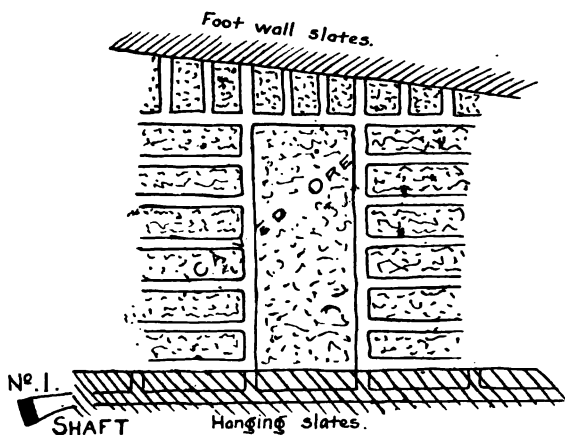


PLATE III, A

Longitudinal Section.

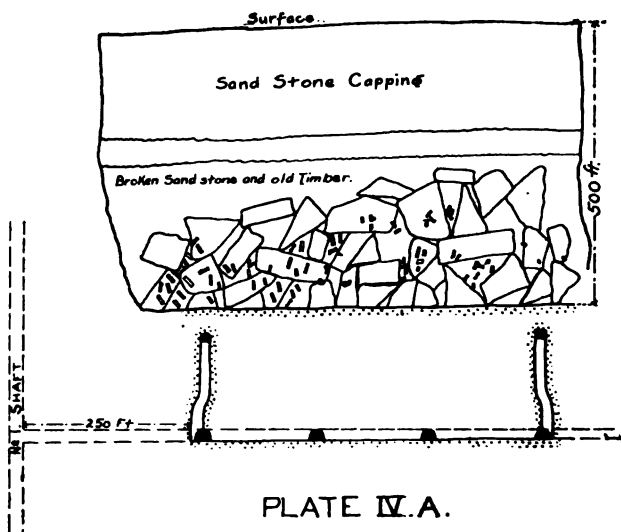


PLATE IV. A.

Cross Section.

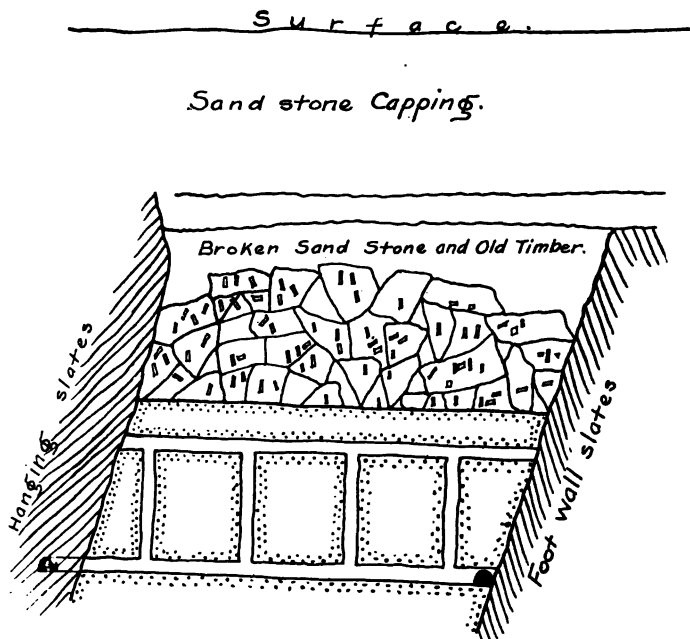


PLATE V. 1.

from these crosscuts drifts are run to the eastern and western boundaries of the caved territory. These drifts are usually located about twenty-five feet apart on the line of the crosscuts, and the general plan of the drifting-work is shown in Plate 3A. The drift nearest the foot wall is connected with the adjacent crosscut, and from this drift short crosscuts are extended, at intervals, to the foot wall.

These drifts and crosscuts are all closely timbered, and after the initial timbering they require but little attention in the way of repairs.

The work of mining is now commenced by allowing the caved ore to run into the drifts and crosscuts through the opening in the end or breast of each. The broken ore is

simply shovelled into the tram cars and taken to the shafts, the breasts of the drifts always being full of broken ore. When a full output is desired, the crew consists of one miner and four shovellers at each of the points in operation. Two of the shovellers are always employed in filling the ore, while the other two are trammings it to the main level. No drilling is required and but little powder is used in blasting this caved or crushed ore.

Drawing the ore in this manner forms funnel-shaped spaces in the body of broken ore, and these are eventually filled by the caving of the timber and broken sand-stone from the old level above. When the ore has been so far removed, at any point, that the waste material is shown in the working-faces, we blast a few of the timbers in the drift and draw our point of operations nearer to one of the main crosscuts. This operation is continued, and repeated until the ore, in the territory formerly traversed by the drifts, has been exhausted and replaced by the waste from above. Other drifts from the main crosscuts are then driven in the pillars remaining between the first drifts, and the operation repeated as in the first work. In actual work it is found possible to draw the ore for three or four feet on either side of these drifts, consequently the second set of drifts practically clean up the broken ore.

The typical block of ore, herein described, was caved during the Fall of 1897. This block contained originally about 350,000 tons of ore and it has yielded about 120,000 tons during the present shipping season. A much larger output could have been obtained if desired.

We have never had any fatal accidents in connection with operating under this system, and it can, without exaggeration, be called a safe method of mining. With modifications to accommodate varying conditions, this system has been applied to the mining of our soft ore bodies, and the results obtained in this direction have been satisfactory to us.

At the Lake Angeline Mine situated near Ishpeming, in

the Marquette District, a method of mining by the system of caving has been practiced for a number of years. The engineer of this mine has kindly given me a written description of it, which is herewith repeated.

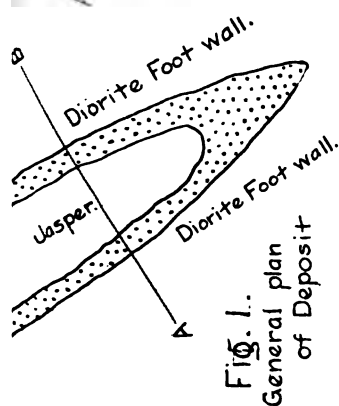
Before describing the method of mining in use at the East End Mine of the Pittsburg and Lake Angeline Iron Company, an explanation will be given of the plates showing several plans and sections of the mine. They are not drawn to scale, simply rough sketches to show the method of mining.

Figure 1 Plate 4 is a general plan of the deposit. Figure 2 Plate 4 is a cross section through AB, showing the location of the shafts in the foot wall and drift crossing deposit. This same drift is shown in Figure 3 Plate 4 crossing the jasper or silicious ore formation forming the hanging of the deposit, and connecting the main working drifts in each side of the deposit, as shown in Figure 3 Plate 4.

From the sketches it will be seen that the shaft is put down in the diorite foot wall, and from which the different levels are driven to and crossing the deposit. From these crosscuts the main working drifts are driven each way lengthwise the deposit, as shown in Figure 3 Plate 4.

At intervals of one hundred feet along the main working drift, raises are put up to the top of the deposit as shown in Figure 3 Plate 4. The raises have three compartments, each about four feet square. The compartments at the ends are used for mills. That in the center is used for ladder-way and timber. The course of the raise is at right angles to the drift and inclines toward the foot. If possible, or if it is convenient, the angle of the raise is about 60 degrees. We find this the most convenient angle for a raise for all purposes. Figure 4 Plate 4 illustrates the above.

The raises are carried up to the top of the ore deposit, and from it, and in the ore directly under the sand or surface material, drifts are driven each way lengthwise the deposit for fifty feet or half way to the next raise as shown in Figure 4



LAKE ANGELINE MINE.

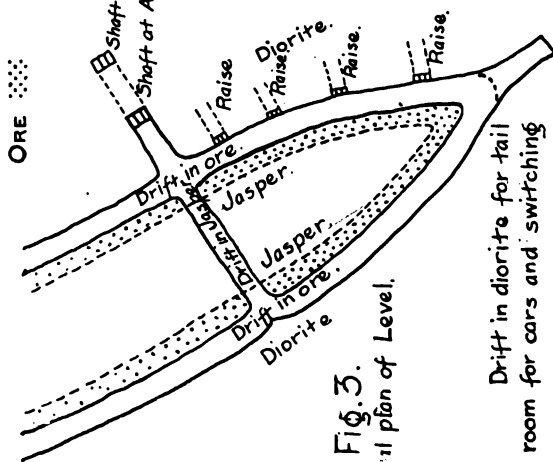
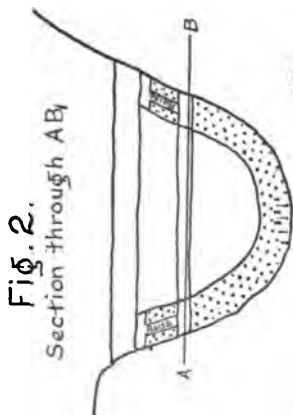
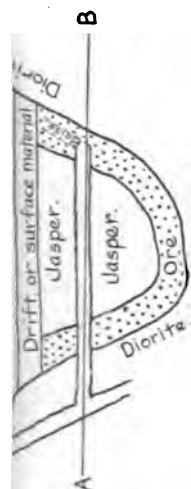


PLATE 4.



Diorite foot



Ore all removed above this level.

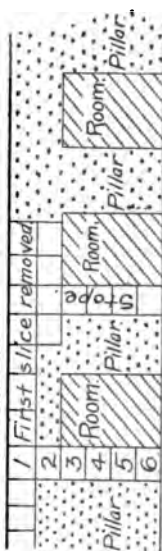


Plate 4. At the ends of these drifts, drifts are driven across the ore body to the foot and hanging. Parallel with these cross drifts, side drifts are taken out in succession until the ground at this level is sliced back to the raise, as shown by dotted line in Figure 5 Plate 4.

The ground or material above the position worked out is allowed to come down itself, or is brought down if necessary for the safety of the workmen.

Immediately after finishing a slice, and before ground above is allowed to fall, the bottom of the workings is covered with poles, lagging, slabs, or any waste material which will form a support to the covered ground while the ore is being removed below it.

This stoping or slicing is carried on until the ore has been mined out down to the main level, or as close to it as convenient, when the operations are transferred to a level below and the ore milled down to it.

The cross drifts in stoping or slicing average about nine feet wide and eight feet high. The timber used for legs and caps is from eight inches to twelve inches in diameter and mostly Norway Pine. The lagging is Cedar and of ordinary size; the poles of any strong timber of convenient size. The distance between the sets of timber may vary to suit the conditions.

At the old Mine previous to the last three or four years, the system used was that of "Room and Pillar," and the upper portion of the mine practically was laid out and worked on that plan. At present all work is on pillars. They are removed in the manner described as follows:

Figure 6 Plate 4 is a longitudinal section through the ore deposit, showing filled rooms "R" and standing Pillars "P." The rooms are lengthwise across the formation from foot to hanging and are about eighteen feet wide and were filled immediately after working from the level above through a Mill "M."

In removing the pillars and floors, a single stope one set wide and extending from foot to hanging is carried up to the workings above as shown by "1, 2, 3, 4, 5." This whole stope may serve as a mill in removing the ore at the sides under the old workings. In removing the ore at the sides, the first slice is taken off immediately under the old working above, and extends half way to the next stope or to "X," and so on, using the caving system. The ore is shoveled or runs directly into the stope and no tramming above is necessary.

The method of mining by the system of caving was made use of extensively in the Queen group of Mines, situated at Negaunee, in the Marquette District, as early as 1890. Previously the method of mining by rooms and pillars had been in use. The large ore bodies which had been honey-combed by this method began crushing in 1889. The shafts located in the ore body were thus wrecked. A sudden settling of the surface over the ore body occurred in the Fall of 1889, resulting in several fatalities and many seriously injured. The failure of the room and pillar method of mining necessitated a change in the system of mining and choice was made of a caving system. It is what is known as the "North of England Method." By this method the developed ore in this wrecked mine was successfully won. No other method could have accomplished as satisfactory results, for the crushed ore was practically all recovered.

When new developments below the wrecked portions of the ore bodies were begun, they were made with a view of continuing the use of the caving system. The shaft to reach the "Regent" lens at these mines was put down in rock alongside the ore body. It followed the pitch of the ore body, i. e., about forty-five degrees. In order that the caving system be successful and economical of time, the overlying burden must settle or cave promptly. Otherwise, with large openings, there might be heavy and dangerous falls of ground. To obviate this, at the beginning of mining in this particular

lens of ore, square sets, as they are called, were used to support the heavy capping immediately overlying the ore. This is shown on Plate 5, at the point A-B. As soon as the capping was moving, and the square sets began to crush, the timber was blasted and the capping let down. This gave the operators a good safe covering so that ore below first level could be won by caving method, and this method has been successfully applied in mining this lens of ore.

A section through openings on sixth level is shown by Figure 1 Plate 5. Up-raises are twenty-five feet or less apart so that miners working in ore from top of up-raises could shovel most of the broken ore directly into the mill. The up-raises are timbered so that two compartments are made, one for ladder-way for men and for hoisting timber through, the other for mill to send broken ore through, with chute at bottom to load the ore quickly into tram cars. Putting up raises so close together obviates the necessity of using tram cars by miners to get the ore into mills and even wheelbarrows are seldom used.

The ore is worked out in slices, or floors, of eight feet in height and timber 7" and 8" in diameter for temporary support only is used.

When ore in each slice is removed, the ore in bottom is covered with waste timber, lagging, etc., to keep waste rock and other material from mixing with the ore, when same is being removed from next slice below.

While this work is being prosecuted on one level, the shaft is sunk for another level, openings and up-raises made to send the ore broken by miners down to new level whenever the timbers in openings on level above crush so badly as to make tramming difficult on that level.

The quantity of ore that can be mined by this method in a given area is illustrated by the fact that in Regent Lens of Queen Iron Mining Company, in a deposit having an area of 286 feet by 147 feet and mining on one level at one time, an

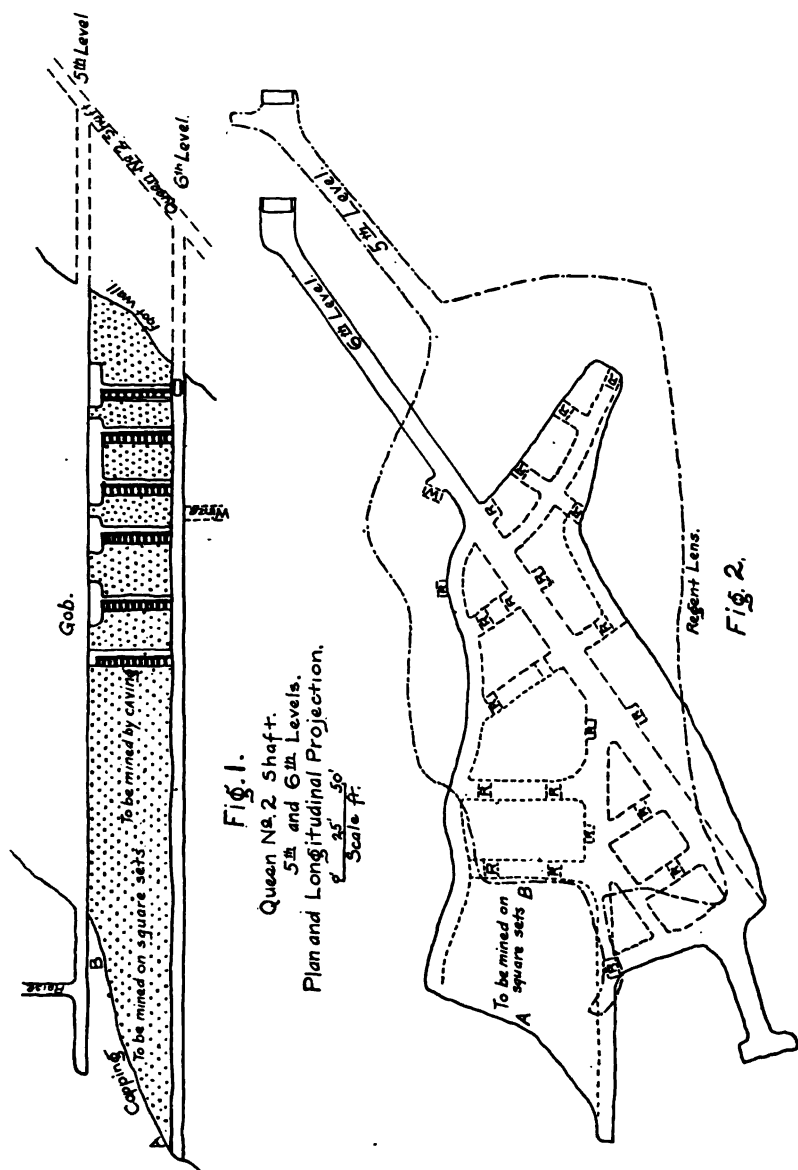


PLATE 5.

average of twelve hundred gross tons of iron ore per day has been broken and sent to surface, and during some days the output has been sixteen hundred gross tons.

Shaft was three compartment, eighteen feet by five feet inside of timbers, two compartments for hoisting ore through, one compartment for water column, steam and air pipes.

Hoisting machinery was duplex slide valve engines, 16"x20" cylinders, geared to drive two 5-foot diameter by 5-foot face hoisting drums. Skips were operated working in balance and three and one-half gross tons of ore were raised at each trip of skip.

At the Chandler Mine on the Vermillion Range, a large product is annually obtained by a method of caving not largely differing from the others described. This mine being so prominent a producer and its ore a brecciated hard ore, makes it seem desirable that the method of mining, by which its ore is won, be accorded a description. The following description of the method used has been kindly furnished me by Mr. John Pengilly, the Manager of the Chandler Iron Co.

The plans marked "Exhibit A" and "Exhibit B" represent the old system of mining, which has been abandoned from the eighth level down.

Above the eighth level we opened the mine with seventy-five feet levels, with four intermediate or sub-levels between the main levels. The ore is dumped down the raises, converted into chutes to the main level, where it is trammed direct to the shafts. The first sub-level above the main level is not opened until we are ready to cave, and, in some instances, is not opened then if the ground shows an unusual amount of weight. To avoid a large opening, our experience so far has taught us to keep our caves as full as possible at all times and that we draw the capping as soon as possible after the ore. If the capping hangs, and does not come at once, there have been times when we have withdrawn our men for safety, until such time as the capping does come. This occurs only at the ex-

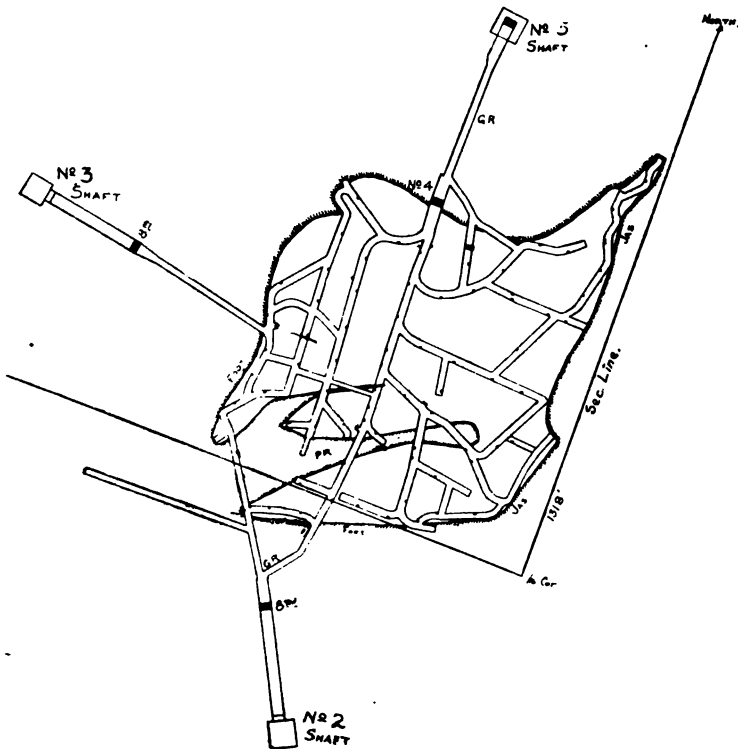


EXHIBIT A.

8TH LEVEL—CHANDLER MINE.

treme east of the property, where we have always had the capping to contend with.

Our eighth level, and above, was originally opened, leaving large pillars. Raises for chutes were put up about every fifty feet to shorten the wheeling distance of the ore into them. It had also been found necessary to put up raises for ladderways to the sub-levels, so that in case of accident we can at all times withdraw our men. The ladderways are not put up by any rule, but as occasion requires.

The main levels are opened with a nine-foot cap and

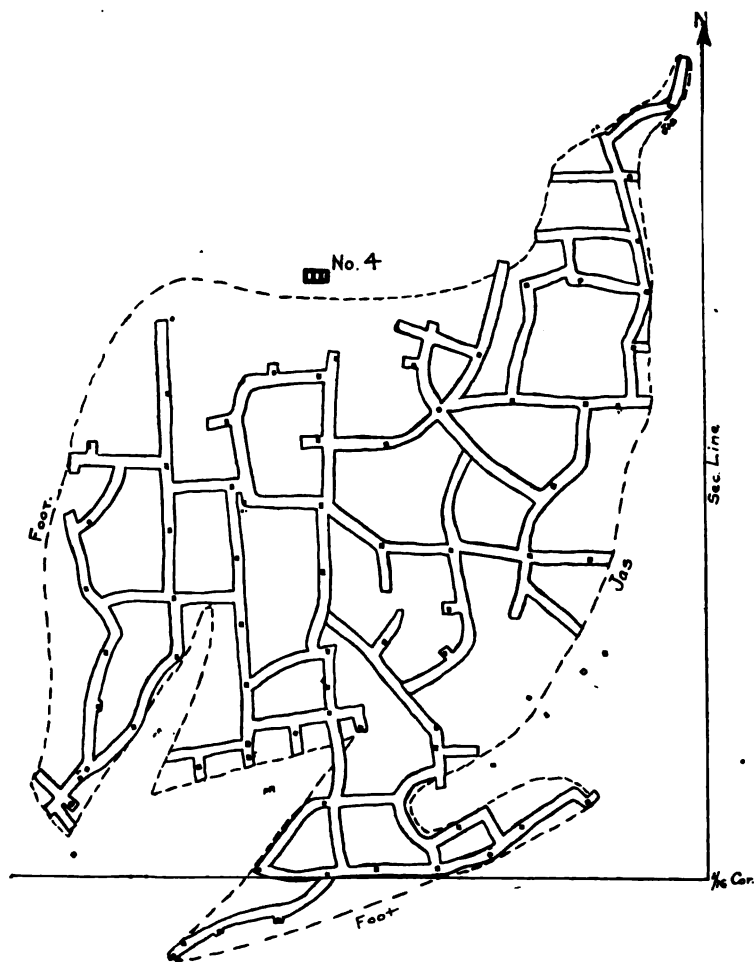
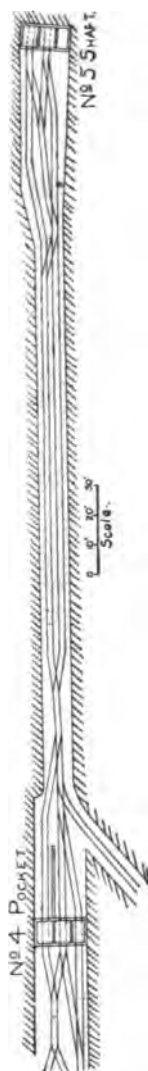


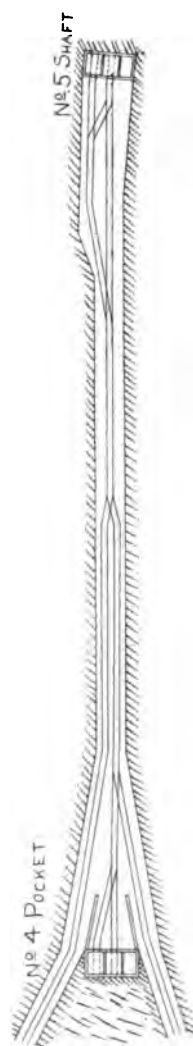
EXHIBIT B.
2D SUB., 8TH LEVEL—CHANDLER MINE.

seven-foot posts, giving in a level seven feet by seven feet in the clear. Our sub-levels are opened with six-foot timber, tunnel shape, three pieces constitute a set.

Our raises are mostly three feet square in the clear. This size we consider easier to maintain from crushing and at



TRACKS ON 8TH LEVEL. GRADE 6" IN 100'.



TRACKS ON 13TH LEVEL. GRADE 6" IN 100'.

EXHIBIT E.—CHANDLER MINE.

the same time it can be guarded to better advantage than a large chute or raise.

When caving, we will run into, or slice, a pillar, and put up convenient raises or chutes for milling down the ore above as may be seen on the eighth plan, or "Exhibit A." Usually we commence to cave on the South and East of the deposit working the caving back in a North Easterly direction, passing or caving such chutes or ladderways as we come in contact with.

Our ladderways are put on an angle of sixty-five to seventy-five degrees. In caving, although we are governed in cases by circumstances and the character of the ore, we always commence at the loose end and draw at all times to the foot wall or dyke.

Timber for sub-levels is thrown down raises from the main level above and distributed from those points.

Our tramming is done principally with mules to the main shafts. At the shafts are stationed a cage tender and an assistant to take the cars off and on the cage. In the station we have a system of tracks for loads and empties, as you will see on "Exhibit E," giving ample room to hold a full train of two or three cars as brought in by the mule, which returns with as many empties. This work is done with a boy and mule.

We have also found it to our advantage to keep our tracks well graded and well drained by ditches cut at the sides of the drifts. Thirty pound rails are used for tracks. This part of our business we consider very important, as it avoids delays and accidents.

The mule distributes empties to the several switches where chutes are being used in the sub-level. These empties are filled by the trammers at the chutes, caves or drifts, and then replaced on their switches, whence the mule hauls them to the shaft. In this way we avoid tiring our men by walking or pushing cars for any considerable distance.

We try to cut down our grade as near as possible to 1' to 100' where tramming is done. 6" to 100' is sufficient grade and will be established by us in the future.

Our hoisting is done on the vertical by cage and on the incline by skips; by high pressure engines and without balance. We have at times three to four levels to hoist from. Mules handle our ore on the surface. The ore on reaching the surface dumps automatically from the skip into a car to which a mule is attached, or if a cage, the mule is hitched directly to the mine car. These cars are trammed or hauled to the stock pile. Empty cars, in both cases, follow the full one into the place it formerly occupied. This is done by means of a system of tracks running through and beyond the shaft house, doing away with the turn table and the transfer car or truck. A load for a mule on the stock pile is two to three two ton cars. In the mine we endeavor to concentrate our men; working them in a certain section and giving a foreman charge of each gang of men, to see that they do a fair day's work and at the same time to protect them from danger. There are not more than ten per cent. of our men who speak the English language, and not more than the above number who have the remotest idea of mining. We do not allow any foreman to have charge of more than twenty-five men.

All ore mined on the seventh level as above is dumped down the old No. 4 shaft, which is used for that purpose as a pocket. It is taken out on the eighth level and trammed to No. 5 shaft, three hundred feet distant to the North. All ore below the eighth level is also dumped down No. 4 shaft or pocket to the thirteenth level, one hundred and ten feet below the eighth level and taken to No. 5 shaft and hoisted. No. 4 pocket has three compartments for first and second grade ore and for rock. Our No. 2 and No. 3 shafts hoist from the seventh and eighth levels and will eventually hoist from the thirteenth.

Below the eighth level we open what is termed in this

mine "Main Sub-Levels," twenty-two feet from bottom to bottom. These levels are known as the 9th, 10th, 11th and 12th Main Sub-Levels. The drifts are opened directly under the main eighth level drifts. The thirteenth level is opened somewhat differently, owing to the pitch of the ore body as will be seen in "Exhibit C," which shows the new system. You will also find a section North and South through No. 4 and No.

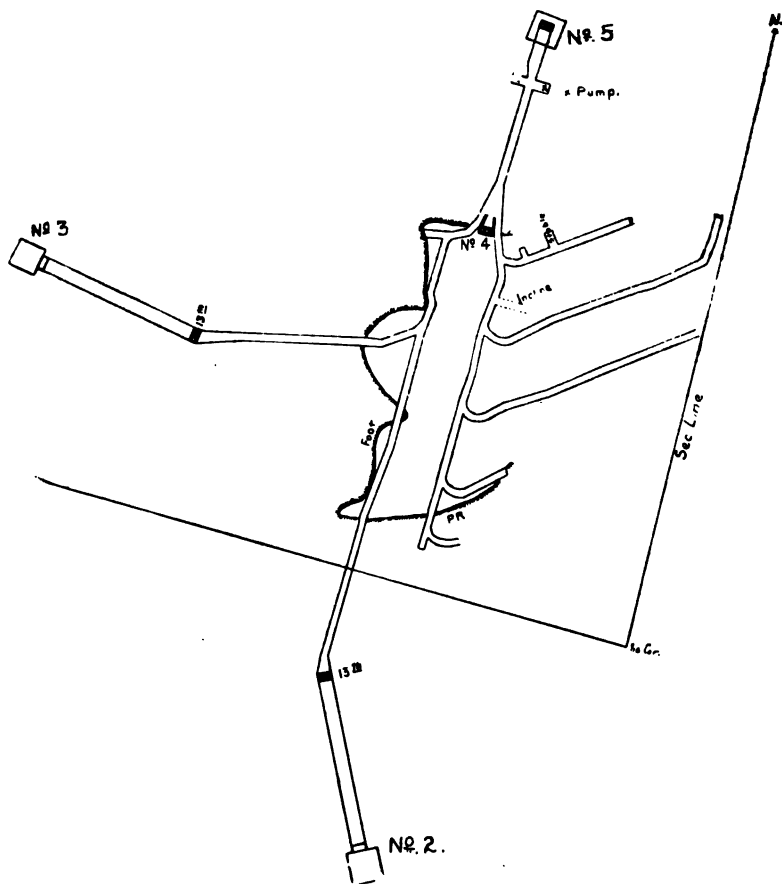


EXHIBIT C.

13TH LEVEL—CHANDLER MINE.

5 shafts, marked "Exhibit D." Also plan of tracks from No. 4 to No. 5 shafts, marked "Exhibit E."

In opening up our main tramming level, we have rock drifts of considerable length from the ore body to each shaft.

The eighth level, "Exhibit A," will show about the average length of such rock drifts, viz., to No. 5 shaft, 310 feet; to No. 3 shaft, 250 feet; to No. 2 shaft, 265 feet. These rock drifts are usually timbered and will measure at least ten feet in clear or inside the timber. In mining our ore, we en-

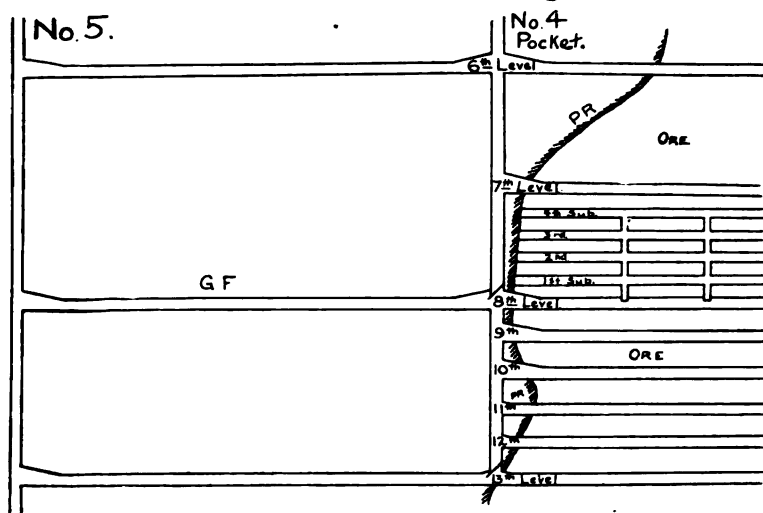


EXHIBIT D.

SECTION No. S, THROUGH No. 4 AND No. 5 SHAFT.—CHANDLER MINE.

counter much rock and clay in the form of horses, seams and bunches. This necessitates careful mining and much rock picking to keep the ore up to grade. On a basis of 600,000 tons of ore mined, we will hoist about 18,000 tons of rock, two-thirds of which actually comes from the ore body and one-third from the rock drifts, shafts, raises, etc., etc.

There has been introduced in the Missabe Range a method of mining called the "Milling System." Many of the Missabe ore bodies lie at no great depth from the surface, and a very

flat dip is characteristic of all of them. When the depth of the overburden of sand and gravel is not great, and the conditions do not warrant the removal of the ore by steam shovels, the so-called milling system is very successfully used. This method involves at the first an entire removal of the overburden of sand and gravel, leaving the uncovered surface of ore very clean. A shaft or shafts are sunk in the adjoining rock and crosscuts and drifts in the ore are driven, which connect with the shafts. Upraises are made at numerous points from the crosscuts and drifts. These are properly timbered to



“MILLING SYSTEM” MILLED DOWN TO LEVEL.
AUBURN MINE, MISSABI RANGE.

serve for ore chutes, with the necessary spouts for loading the ore therefrom into tram cars on the levels or crosscuts. When the preparations for mining ore are completed, the ore about the upraises is blasted into them. It is drawn from them into the cars stationed in the levels as rapidly as the facilities for handling the ore to the surface permit. The ore being very soft, upraises are made at slight expense. The raises, closely spaced in the ore body, enable the winning of ore to be



"MILLING SYSTEM," SHOWING CHUTE OF MINE.

AUBURN MINE, MISSABI RANGE.



EASTERN END OF PRODUCTION PORTION.

BIWABIK MINE, MISSABI RANGE.

accomplished at a minimum of expense. It is evident that there is no lifting of the ore whatever by manual labor. In the blasting, much ore is tumbled directly into the chutes, and the unskilled laborers drag or push the ore down the slopes and into the chutes by their shovels with a minimum of effort. By this method of mining, the product of ore per day per man is very great. The waste of ore in this method of mining is practically nothing.

A large tonnage of the Missabe ores is annually produced by steam-shovel mining. About 50 % of the Missabe Range



"STEAM SHOVEL MINING."
MAHONING MINE, WEST END MISSABI RANGE.

product in 1898 was thus produced. This method of mining requires that the over burden of gravel and sand be removed so as to leave the uncovered surface of the ore body practically clean. A bank or bench of ore twenty feet high is found generally most advantageous. A higher bench will often give trouble by caving on the steam shovel at the time of blasting. Although the Missabe ores are soft, yet as they lie undisturbed in the bed, they are too coherent to be shoveled without being

blasted. In some of the mines there are hard strata, against which a steam shovel is not economically effective. The holes for blasting the ore are drilled by hand. Drawing the drills consumes much time. They are usually fifteen to sixteen feet apart and nine feet from the edge of the bench. They are driven fifteen feet deep. Steel drills one and one-eighth inch in diameter are used. Men will drill three holes per day at the Mountain Iron Mine. For cracking the holes at the bottom to make a cavity for a charge of black powder, three one-pound



“STEAM SHOVEL MINING.”

MOUNTAIN IRON MINE, OLIVER IRON & MINING CO., MISSAHI RANGE.

sticks of 40% giant powder are used. Steam shovel mining, to be economical, requires that there be no delays in the work. Large tonnage is possible when conditions are all favorable. Two hundred and thirty-two cars, containing five thousand eight hundred and twenty-five tons, have been loaded at the Mountain Iron Mine in nine and one-fourth hours by a ninety-ton Vulcan Shovel. The best record for one hour has been thirty-two cars, or eight hundred tons.

After the reading of the paper, voted that owing to the lateness of the hour, the discussion be dispensed with.

On motion the Society adjourned at 10:30 P. M.

REGINALD A. FESSENDEN,

Secretary.

MEETING OF THE CHEMICAL SECTION.

PITTSBURG, PA., February 24th, 1899.

The regular monthly meeting of the Chemical Section was held February 23d, 1899, in the rooms of the Society.

Chairman, Dr. E. S. Johnson.

Attendance, 15.

There having been no monthly meeting held after the adjournment of the annual meeting in January, the minutes for the December meeting were read and approved.

Messrs. Phillips, Stahl, and Handy were appointed by the Chairman to serve as the Committee on Chemical Literature for the coming year.

After some discussion as to the advisability of appointing at present members to serve on the Sanitation Commission, it was decided to appoint a committee with the understanding that the members should be ready to serve should the occasion arise.

The following Committee was appointed by the Chair :

Messrs. Phillips, Camp and Stahl.

The paper for the evening, on the application of artificial dye-stuffs, was then read by Dr. Johnson, Dr. Phillips taking the Chair :

A BRIEF REVIEW OF THE MORE IMPORTANT SERIES OF ARTIFICIAL ORGANIC DYE-STUFFS.

BY EDWARD S. JOHNSON.

II. COLORING MATTERS OF THE TRIPHENYLMETHANE, ANTHRAQUINONE AND AZO- SERIES.

C. APPLICATIONS.¹

DYEING.

The main consumption of the artificial coloring matters is as dye-stuffs for organized matter, largely in the form of animal and vegetable fibre.

The union of the principals, dye and fibre, has before been described in the purposely general terms of the phrase, "a species of firm incorporation." The expression then served the sufficient motive of a mere suggestion, the more appropriate present connection has intentionally been reserved, as its logical place, for the analysis of the phenomenon and more precise definition of its nature. Thereby the theory underlying the characteristic processes of the dyer's art will be developed; no attempt will be made to present the technology of the subject farther than concerns general outlines of procedure.

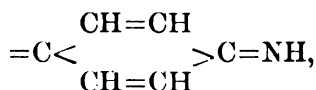
THEORY OF THE PROCESS.

The character of the inner process, the incorporation, which is the fixing of the coloring matters with the perma-

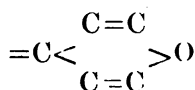
1. In dealing with the application of the coloring matters, a departure from the limits prescribed in the foregoing discussion will be taken in order to refer to certain compounds of special interest belonging to other series, notably the colors gallocyanine and gallamine blue (oxazines), methylene blue (a thiazine), primuline and the quinolines are in mind.

nence demanded, if they may be designated dye-stuffs, is still a matter of discussion.

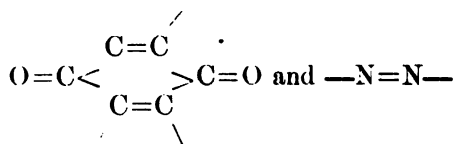
A widely applicable and credited theory as to the nature of the combination between fibre and dye-stuff was developed by Witt. In each coloring matter, according to this investigator, there exists a certain aggregation of atoms called a *chromophore*. The simplest of such atomic complexes is the nitro-group, —NO_2 . Usually they are more complicated, containing, besides carbon, elements such as oxygen, sulphur and nitrogen, which give rise to slightly acid or basic quality: they exist in general in cyclic combination, and, with the exception of the nitro-group, are dyad and of still higher atomicity. It is moreover characteristic that the molecule of which they form a part contains numerous carbon atoms; the same chromophore under reversed conditions, in combination with few carbon atoms, is inefficient. Among the colors of the amidotriphenylmethane group, it is the complex,



and in the derivatives of fluoresceïne in part the combination



which represent the capacity of the compounds containing them for the development of colorific properties. The same function is performed among the anthraquinones and azo-colors respectively by the complexes,



Bodies containing such aggregations are empowered to generate coloring matters and are the *chromogens* of Witt.

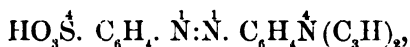
Their presence alone is insufficient to impart to the compounds ability to permanently attach themselves, after the manner of a dye-stuff, to the textile fibre. This is acquired by substitution in the chromogen of *salt-forming* radicals such as hydroxyl, the amido-, sulphonic and carboxylic groups. Among these, hydroxyl and the amido-group have a more marked influence than the last named. Besides in giving increased acid or basic quality to the chromogen, they modify the properties of the coloring matter generated from it, especially by increasing the intensity of color; the chromogen may even first become a colored substance by the substitution of such radicals. They are known as *auxochromic* groups to distinguish them from the carboxyl- and sulphonic groups, whose assumed important office is to mediate the attachment of the dye to the fibre.

It is a plain deduction on this assumption, that, should a chromogen of acid tendencies be substituted by a basic auxochromic group, the effect would be an intramolecular neutralization and a failure to produce a desired cumulative result. The dye-stuff characteristics of trinitraniline, $(\text{NO}_2)_3 \text{C}_6\text{H}_2\text{—NH}_2$, are practically null; those of trinitrophenol, $(\text{NO}_2)_3 \text{C}_6\text{H}_2\text{—OH}$, are strongly pronounced. In the former a partial neutralization of the chromophore has taken place by the entrance of the basic amido-group; in the latter, on the other hand, the presence of the acid hydroxyl with the already acid nitro-groups is additive in effect. The basic, salt-forming imid-group (=NH) of the chromophore of rosaniline and its derivatives is effective to the remarkable degree displayed by the compounds containing it by virtue of the presence of two amido-groups with a resulting accumulation of basicity. In the anthraquinones, the negative, chromophoric keton-groups (=C=O) of the molecule are enhanced in acidity by the acid hydroxyls, etc.

This relationship has been summarized by Witt substantially as follows: Of two analogously constituted dye-stuffs, the more basic or the more acid is the better.

The general observation that compounds constituted as described are coloring matters of pronounced characteristics, leads naturally to the supposition that the union of dye-stuff and fibre is a chemical phenomenon, and, more explicitly, in nature a salt-formation. This view, the *chemical theory of dyeing*, is supported by experimental evidence, both qualitative and quantitative, as regards animal fibre, and that of vegetable origin, as well, after the preliminary treatment with mordants.

A hot solution of colorless rosaniline base produces upon wool or prepared cotton immersed in it an intense coloration as when dyed with the salts of the base, the characteristic fuchsine red: the fibre or some constituent of it has acted the part of an acid, in the language of the theory, and united with the color-base. The numerous sulphonated azobenzenes and related colors impart a color contrasting strongly with that of the free sulphonic acids of which they are salts. The colorings are identical with those produced by the combination of the sulphonate and a base. Methylorange, sodium salt of dimethylamidoazobenzenemonosulphonic acid,



for instance, dyes wool and silk, not red, the color of the free acid in solution, but orange, the color of its alkali salts. The fact that the salts of many of the dye-acids (sulphonates of the rosanilines and azobenzenes) require the addition of an acid capable of decomposing them, before the color-acids can act as dye-stuffs, has been suggested as further evidence that the attraction of the fibre for such substances is chemical affinity. The action of the acid is to set the color-acid at liberty to unite with the fibre in which the existence of a basic component is assumed.

That cotton fibre when prepared by basic or acid mordants fixes the same colors, by an undoubted chemical combination, as do wool and silk directly, creates by analogy the presumption that the action of these fibres is of the same nature, a salt-formation.

The assumption of both acid and basic properties in fibre behaving as thus indicated, has passed the stage of hypothesis and become a theory of repute. It is in likening the behavior of the fibre to that of the amido-acids, of both basic and acid qualities, such as amidoacetic acid, $\text{CH}_2(\text{NH}_2)\text{—COOH}$, alanine, $\text{CH}_3(\text{NH}_2)\text{—CH}_2\text{—COOH}$, tyrosine, $\text{C}_6\text{H}_4(\text{OH})\text{—}\overset{\cdot}{\text{C}}\text{H}_2\text{—CH}(\text{NH}_2)\text{—COOH}$, etc., that the supposition is entertained. Direct experimental confirmation has been found in the isolation of compounds of this nature from the decomposition products of wool by alkalies. That identical or analogously constituted compounds form salts with a number of the dye-bases, as shown by experiments of Gnehm and Rötheli,¹ supports the assumption of a chemical union between similar constituents of the fibre and the color-bases.

A substance of acid properties containing carbon, hydrogen, oxygen, sulphur and nitrogen has been separated from wool by Knecht,² and is known as *lanuginic acid*. The compound, a white amorphous substance, in aqueous solution forms insoluble combinations with all those dye-stuffs which are directly fixed by woollen fibre, the color in each case being the same as that produced by a given coloring matter upon the fibre. These facts render the existence of chemical union between constituents of the fibre and the color in dyeing probable, if they do not positively demonstrate it. The similar examination of a solution of silk in caustic alkali has shown the presence of a compound called *sericinic acid* with properties analogous to those of the corresponding compound from woollen fibre. The similarity of the reactions of the two acids

1 Zeitschr. f. angew. Chem., 1898, pp. 501-505.

2. Hummel-Knecht: *Färberei u. Bleicherei d. Gespinnstfasern*, 2 te Aufl., 26.

offers an explanation of the almost parallel behavior of wool and silk in relation to the coloring matters.

Evidence of a quantitative character for the chemical theory is, for example, the fact that in dyeing with fuchsine, rosaniline chloride, the whole of the acid combined with the base withdrawn by the fibre from the dye-bath is found in the latter. The same behavior is manifested by the salts of amidoacetic, amidocaproic, amidostearic, amidopalmitic, stearic and palmitic acids, and tyrosine with the base of new fuchsine. In alcoholic solution these compounds dye the animal fibres; the acids remain in solution. Other experiments have been conducted with stearates and palmitates of various basic coloring matters. Extraction of animal fibre, dyed by them, showed the absence of even a trace of fatty acids upon the fibre. The acids separate quantitatively from the dye-salts, the bases uniting with the fibre.¹ Experiments by Knecht show, moreover, molecular relations among the quantities of certain dye-stuffs taken up out of hot solution by wool with the coloring matters in large excess. The results obtained are given in the following table :

	Calculated.	Found.
Picric acid.....	— %	13.3 %
Naphthol yellow, 8 (1 mol.)	20.6 "	20.8 "
Tartrazine ($\frac{3}{4}$ mol.).....	23.1 "	22.6 "
Crystal violet ($\frac{1}{2}$ mol.).....	7.94 "	8.4 "

The quantity absorbed by picric acid is taken as the unit.

Among principal defenders of a general application of the chemical theory, besides Knecht, may be mentioned L. Vignon, who ascribes the fixing of even the substantive cotton-dyes to chemical affinity.²

While offering a generally satisfactory explanation of the phenomena of dyeing as observed in connection with wool, silk and mordanted cotton, the chemical theory is insufficient,

¹Gnehm u. Rotheli : *Zur Theorie des Färbungsprocesses*, *Zeitschr. f. angew. Chem.*, 1888 pp. 482-88, 501-505.

²Leo Vignon : *Comptes rendus d. l'academ. des sciences*, 125, pp. 357-60, as reviewed by Hess : *Chem. Central-Blatt*, 1897 II., 651.

in not comprehending the direct fixing of such coloring matters as primuline, and those derived from benzidine and other bases of like quality by cotton fibre, and the nature of its affinity for the basic and acid mordants. The same difficulty is experienced in understanding from a chemical point of view the coloring of precipitated sulphur, glass, clay, asbestos, etc., by a number of basic colors. Barium sulphate further may be tannated and dyed with fuchsine; with addition of salt, the same substance fixes benzopurpurine and similar (benzidine) colors.

It is further urged against a reference of the phenomena of dyeing to chemical affinity as a cause that the textile fibres in general take up comparatively more coloring matter from very dilute, than from concentrated, solution, the dye being held then with such extreme tenacity that it is impossible, as a rule, to remove it by washing with a solvent, although the more intense colorations are extracted frequently so copiously as to indicate the possibility of a complete removal.

The part taken by capillarity in the formation of a coloration has been pointed out as a main cause, and as against the chemical and other theories that have been advanced for its explanation. Asbestos in a finely fibrous condition, although practically with no chemical affinity for dye-stuffs, fixes them in notable quantities. The important part played by the structure of the material, as thus instanced, prevents, it is argued, a direct comparison of the colorations upon the textile fibres with chemical compounds and solutions (see below).

The deficiency of the chemical theory, in connection with the phenomena discussed and others which must be passed over, has caused the advocacy of the *mechanical theory*, according to which the process is a surface attraction, a form of adhesion. The chief advocate of the theory is Georgievics.¹ In the contention Witt³ has assumed in his *solution theory* an

1. Compare *Wagner's Jahres-Bericht*, 1894, pp. 1001-1011.

3. *Färberzeitung*, 1890 and 1891.

intermediate position, and compares the action of the fibre upon the dye-stuff to that of ether in extracting a substance from its aqueous solution, and the dyed fibre to a solid solution like that of a metallic oxide in a solidified glass fusion. Further analogy between solution and the interaction of the fibre and coloring matter is furnished by phenomena observed in dissolving dye-stuffs such as fuchsine, methyl violet, etc., by water and other solvents. In solid form these substances are not seen, under usual circumstances, in their true color, but in the complementary, superficial colors; the colorations upon the fibre dyed with such color-compounds are those of their solutions, not those of the solid substances. The fluorescence of colorations upon silk by the eosines, rhodamines, and similar compounds whose solutions likewise fluoresce furnished Witt with an additional point of resemblance between the dyed fibre and a solution. The likeness is, moreover, borne out by a consideration of the facts that certain of the coloring matters only are substantive in their relation to the textile fibres, that is, attracted by unmordanted fibre, and that the solubility of any soluble substance varies in the same manner with different solvents.

Commenting upon the discussion, Nietzki¹ remarks: "It is here the more difficult to take position in favor of one or the other view, inasmuch as the differences among chemical combination, solution, and mechanical attraction can, by no means, be defined with perfect sharpness."

The literature of the last few years indicates a growing recognition of the applicability of all the main conceptions suggested, rather than insistence upon a single theory for the phenomena exhibited. Thus C. O. Weber² contends firmly for chemical affinity as the cause of the union of the dye and fibre in the case of the basic and acid dyes upon wool and silk; for cotton fibre and the benzidine colors, the solution theory

1. *Chemie d. organ. Farbstoffe*, 2te Aufl., p. 5.

2. *Färberzeitung*, 5, 161.

is accepted, not as conceived by Witt, who represented the color in solid solution, but modified to indicate the fixing of the color by diffusion into the fluid within the cell of the fibre. The color is retained by an extremely low coefficient of diffusion.

Gnehm and Rötheli,¹ in a recent review of the comprehensive experiments and observations of other investigators, conclude, in confirmation and partial extension of the opinions already formulated, that the dyeing of the various textile fibres is not uniformly of the same nature. That of vegetable fibres does not depend upon the same processes (or only in part) as that of the animal fibres. In the case of the latter, the formation of the coloration in each instance is not a simple, but rather a compound, process in which chemical reaction and mechanical forces (adsorption phenomena) participate. Colorations upon mordanted cotton are regarded by the authors as lakes between the mechanically precipitated mordant and the dye-stuff; pigment colors and azo-colors produced upon the fibre are purely mechanical precipitations; indigo and basic, substantive cotton dyes are also held by the force of adhesion in the sense of Georgievics; direct colorations upon cotton by the benzidine dyes are solutions of the dye-salts in the cell-fluid of the fibre, made possible by a slight coefficient of diffusion; mordanted wool and silk are conceived to be dyed by a lake-formation (without participation of the fibre unless the latter be in chemical combination with the mordant) of the dye-compound with the mordant which is partly chemically, partly mechanically, fixed; finally, the substantive dyeings upon animal fibre result from a chemical combination of the color-compound with the fibre, and from the simultaneous admixture of mechanically adhering dye-stuff.

¹Hefelmann: Abstract in Chem. Central-Blatt, Gnehm u. Rötheli: *Zur Theorie des Färbungsprocesses*, 1898 II., pp. 152-3.

PRINCIPLES AND OUTLINES OF THE PRACTICE.¹

The chemical composition of the textile fibres, wool containing carbon, hydrogen, oxygen, nitrogen and sulphur, with its complex amido-acids, silk of related constitution, and cotton, the carbohydrate, cellulose, makes it but a fair deduction that contrasting behavior would be displayed by the latter, as compared with wool and silk in relation to the coloring matters. This partially accords with actual experience. A skein each of wool, silk and cotton, to illustrate, when removed, after a few minutes' immersion in a hot solution of methyl violet, and washed, show at a glance decided differences in attraction for the dye-stuff; the woollen and silk fibres have been permanently and intensely colored, while the cotton at most has undergone slight discoloration. A similar differentiation is manifested by the respective fibres toward other amidotriphenylmethanes; the colors of the related group of phthaleines, the eosines, phloxines and rhodamines, are likewise attracted by wool and silk, but indifferently or not at all by vegetable fibre; in general, wool and silk evince for the basic, oxy- and acid colors a direct affinity, cotton behaving with indifference. Among the azo-colors, however, is a comprehensive group of dye-stuffs which directly unite with both animal and vegetable fibre. Coloring matters of whatever origin and of this quality are described as *substantive*. Opposed to these are the *adjective* colors which can be firmly fixed upon the fibre only after preparatory treatment of the latter. These obviously are prime considerations for the colorist; the necessities which they impose have given rise to the procedures of *direct* and *mordant dyeing*.

1. MORDANTING.

Whether without natural affinity for colors of certain groups or producing with them colorations of indifferent value,

1. In the preparation of the chapter on *mordanting* and *dyeing*, and the subsequent one on *printing*, among others, the works, Hummel-Knecht: *Farberei u. Bleicherei d. Geopinnfasern*, Sansone: *Der Zeugdruck*, and *The Coal-Tar Colors of the Farbwerke vormals Meister, Lucius & Brünig* have been of material assistance.

the textile fibres may be qualified as desired in the respects implied by a rational process of mordanting. This essentially consists in imparting an acid or basic property in accordance with the nature of the dye-stuff and the principles of the chemical theory of dyeing; if it be *basic* in character, an *acid mordant* is employed, and *vice versa*. The amidotriphenylmethanes and the adjective basic azo-colors, for example, are fixed upon cotton materials which have been mordanted by an acid; given a basic quality by mordanting, it firmly incorporates such acid dye-stuffs as the sulphonated oxy-derivatives of azobenzene and -naphthalene, etc.

Besides, as just instanced, in simply inducing the capability of combination between fibre and coloring matter, mordants have the additional very important function of generating with the same dye-stuff two or more colors, each corresponding to the mordant employed. In allusions already made, whatever the mordant, the colors produced by a single dye-stuff are the same or only slightly modified in tone; cotton, however mordanted, is dyed by fuchsine a characteristic red; the salts of rosaniline, in other words, are uniformly of the same color. Other coloring matters, typically alizarine, yield a series of brilliantly colored salts, the color in each case being dependent upon the base entering the combination. To coloring matters developing a single color, no matter how its union with the fibre be accomplished, the term *monogenetic* has been applied; mordanting has *sensitized* the fibre. Dye-stuffs producing colors varying in kind according to the mordant used are designated *polygenetic*; the mordant has served as a *developer of color*.

Principal among the compounds with the function of *basic mordants*, may be mentioned salts of aluminium, iron and chromium; subordinate in extent of application and in part of the character of assistant-mordants in the formation of compound lakes, salts of tin, copper, nickel, cobalt, zinc, calcium and magnesium, should be noted. The aluminium compounds

chiefly employed are the sulphates, the potassium and ammonium alums, and acetate; iron is used in the form of ferrous and ferric sulphate and acetate, and as nitrate; potassium bichromate is the most abundantly consumed salt of chromium; stannous and stannic chlorides serve to fix tin upon the various fibres, etc.

The mordanting of materials to be dyed is a process dependent principally in details upon the nature of the fibre, the mordant and the coloring matter.

Wool and *silk* in general are immersed in a solution of the mordant and steeped from one hour to twenty-four at temperatures varying from the ordinary to the boiling. Short exposure in hot, moderately dilute solution, is usually adopted for wool; silk, although frequently treated in warm or hot solution, is perhaps more generally mordanted in the cold in concentrated solution. The presence of the fibre, together with dilution and heat, if the latter be applied, causes dissociation and the formation of basic salts, which are held in combination with the fibre by its lanuginic or sericinic acid,¹ according as wool or silk is concerned. The addition of tartaric acid, acid tartrates or oxalic acid is often made by way of facilitating the dissociation; where aluminium sulphate, for instance, is the mordant, tartrate or oxalate is formed. These more readily suffer decomposition under the given conditions than would the original sulphate.

Another view explains the process as purely mechanical, a precipitation of basic salt within the fibre, which then retains it firmly by adhesion.

With no natural fixing-agent, such as exists in wool or silk, according to the first conception as to the nature of the union of fibre and mordant, resort must be had in the preparation of *cotton*, for use with the acid coloring matters, to artificial means. After thorough saturation of the fibre, removal of the excess of mordant by wringing, and drying, the material

¹Hummel-Knecht: *Färberei u. Bleicherei d. Gespinnstfasern*, p. 26.

is passed through a solution of ammonia, sodium carbonate, phosphate, silicate or arsenate. An hydroxide, a basic or other insoluble salt is deposited.

When practicable, acetates, which are readily decomposed by heat and solution, are used. The advantages are easy preparation upon the materials, and especially a free acid from the decomposition, which is not injurious to them. The basic acetates are formed by aging, exposing the treated fabric to moist, warm air, or by steaming. The latter operation is widely applied to printed goods upon which mordant and color have been brought simultaneously.

The *acid mordants* serve mainly in the preparation also of cotton for dyeing with basic colors. Wool and silk, with their natural attraction for these substances, enter less into the discussion.

In number they are but limited, the main members of the class being tannic acid and certain of the fatty acids in the form of salts, notably oleates and palmitates of ammonium and sodium.

Cotton fibre has a peculiar affinity for *tannic acid*, absorbing, or in a sense, extracting it from solution. For instance, saturated in a solution of given strength, the fibre is still capable of increasing the amount already withdrawn when immersed in one of considerably weaker content. A limit is reached by continued dilution, the extractive action of the solvent then overpowering that of the fibre.

As an acid, tannin unites with the basic coloring matters, producing, under the proper conditions, insoluble tannates. If the acid be deposited upon and within the fibre, its combination in dyeing with the coloring matters, or lake, will likewise be fixed there, and by the same force which may be described as adhesion.

Tannic acid further combines with the metallic oxides; the lakes thus formed are able to bind the dye-bases and thus themselves may act as mordants. Many of such triple com-

pounds, principally those derived from salts of aluminium, antimony and tin, excel, by virtue of increased insolubility, in fastness the simpler tannates of the dye-stuffs, and are accordingly of much practical importance. Dyeings produced upon tannated cotton by the basic coloring matters are, therefore, made the more permanent by treatment with these reagents. They serve as fixes as do the phosphates, carbonates, etc., in applying the basic mordants and acid dyes to cotton.

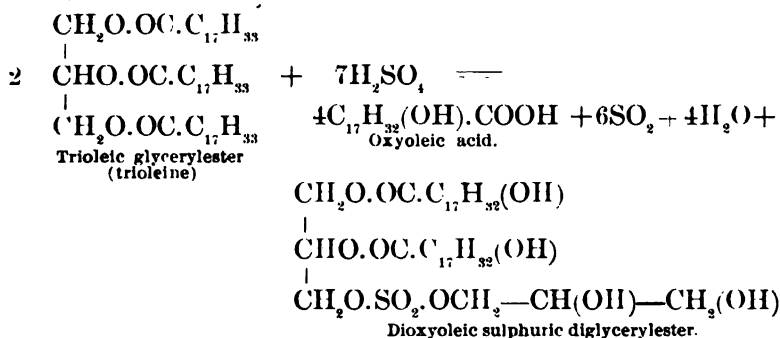
The tannating is accomplished by steeping, in a hot solution at the start, for 12-24 hours, the solution being allowed to cool before the material is removed. The time of the preparation may be shortened by padding, soaking for a few seconds in warm concentrated solution. In either method it is necessary to fix the mordant, render it insoluble; this is done by immersing the goods for a few minutes in a bath containing a salt of antimony, stannic chloride, or other compound of like effect, after expressing the excess of tannin solution.

The use of the *fatty acids* as mordants is a legacy of ancient civilizations. Their value, in connection with the famous madder dyeing of the Hindoos, and much later, in the production of Turkey-red, makes them of especial interest, aside from their present importance. Butter-fat applied as milk is said to have furnished the dyers of ancient India a reagent for developing their celebrated red upon cotton fabric. Among the Turks, olive-oil serves a similar purpose. The fiery Turkey-reds of to-day are obtained with artificial alizarine and preparations from both olive- and castor-oil in the presence of a calcium salt and an aluminium mordant.

Like tannic acid, the fatty acids form with the metallic oxides compound mordants. With tannin their action is that of a fix. The points of view are reversed in using the fatty acids; the organic acid is the fixing agent, while the metallic oxide is the mordant, and, in addition to this, the developer of color.

The fatty acids are employed as olive- or castor-oil,

emulsions of these, and as alkali salts. Another much-used preparation is the so-called Turkey-red or sulphated oil, resulting from the action of concentrated sulphuric acid at a moderate temperature (30° – 35°) upon the oil mentioned, and neutralization with ammonia after the removal of an excess of acid by washing with salt solution. Some discussion still prevails as to the action of the acid. A generally quoted view represents the process to be an esterification and oxidation combined. Using olive-oil which is essentially trioleic glyceryl-ester, the reaction is



The oil-mordants are used only in cotton dyeing, and chiefly in connection with the alizarine colors. The mode of application as Turkey-red oil is simplest. The washed fabric or yarn is soaked in warm aqueous solution of the preparation, wrung and dried. This is known as the rapid process. The remaining two older processes require much longer time and numerous manipulations. The mordant is an olive-oil emulsion with dilute sodium carbonate solution, and is applied warm and repeatedly, the material being exposed to the air after each application. In a somewhat modified process by Steiner, the goods are passed into hot oil, wrung, and hung in air chambers, heated to 70°C. , for two hours. Following the oiling they are steeped in soda solution and again exposed in the hot chambers; the treatment with soda and the heating are several times repeated.

As possessed of direct affinity for the fibre or fixed by mordants upon it, *coloring matters* containing acid salt-forming groups of atoms may themselves act as acid mordants. Examples are to be found among the substantive cotton dyes of the benzidine group; cotton fibre upon which alizarine has been fixed is directly dyed by the basic colors.

2. MONOCOLOR DYEING.

Usually a first step in the preparation of natural fibre for dyeing is a thorough *cleansing* and *bleaching*. Either for the reception of the mordant or the dye-stuff, these operations evidently are indispensable. An ununiformly oily fibre, for instance, would resist successfully a uniform action of both agents. The result would be a disturbing unevenness of effect. Discolored materials plainly would militate against cleanliness of appearance and clearness in dyeing delicate shades.

Wool especially must be freed from much grease naturally present, and, when woven, from oil and other aids employed during spinning.

Silk is carefully treated with soap solution for the removal of the coating of the fibre proper; the washings, called "boiled-off liquor," are saved for use later in the dye-bath where they restore lustre to the material, and further play an important intermediate part as a carrier of the coloring matter from the dye-liquor to the fibre.

Cotton of all the principal textile fibres is subjected least to washing and bleaching. Boiling with dilute soda solution usually suffices; bleaching becomes imperative only in the production of light shades of color.

These preliminaries accomplished, the fibre (it may be unspun, as yarn, woven, natural or mordanted) is then ready for *dyeing*.

Although the mordanting by implication has been considered as though preceding the dyeing, in this order is most generally carried out, and then, as a rule most advantageously,

it may in special cases be simultaneous with, or even succeed, the application of the coloring matter.

Wet or moist, the goods are brought into the warm solution or suspension of the color or colors and kept constantly in motion while the temperature is slowly raised to, or nearly to, boiling. The numerous precautionary measures adopted against defective results, as "spottiness" or "unlevel shades," arising in faulty handling of the materials, the composition of the dye-bath, and the nature of the coloring matter, can not be rehearsed in detail; they must be dismissed with a few general, illustrative comments upon phases of the process which seem of special interest mainly from a chemical stand-point.

The affinity of dye and fibre, tendency to tarry precipitations, as may be the case with some of the basic colors and the very insoluble color-acids, may, for instance, become factors of unsatisfactory colorings which require most careful adjustment of both the manipulation of the goods and of the ingredients of the dye-flot.

Where the color is strongly attracted, the conditions are favorable to cloudiness, streakiness, and other similar effects; that they would be magnified by slight physical and chemical inequalities, which may easily exist in the materials to be dyed, is equally plain. Dilution of the bath, slowly increasing its temperature after entering the goods, and regular, energetic handling of them are suggested as physical remedies. Chemically recourse is had, if acting on acid or acid-mordanted fibre with basic dyes, to slight additions of acetic acid to an usually neutral or a nearly neutral bath. If the coloring matter be of acid character, it is necessary, that the color-acid may be liberated from its salt for combination with the base of the fibre or its mordant, to add portions of a mineral acid, usually sulphuric; the employment of weaker acids, hydrochloric, oxalic, tartaric, acetic or their ammonium salts, of old dye-liquor in preparing the flot, and of increased quantities of the sodium sulphate customarily used with the acid colors, all

modify the attraction of the fibre for the color, retarding their interaction in the interest of *level dyeings*.

The *spottiness* from precipitation in baths containing the basic colors is greatly reduced or entirely prevented, so far as the coloring matter alone is concerned, by acidification with acetic acid. Resinous agglomeration of certain of the difficultly soluble dye-acids at the higher temperatures of the bath, with attending formation of spots, is guarded against by the use of perfect solutions of the salt of the color-acid, carefully introducing them into a dilute acid bath with the object of having the dye-acid separate in a fine state of division, and then entering the goods; or the operation is reversed by boiling the material with the color-salt alone and acidifying gradually with sulphuric or other acid to slowly liberate the dye-acid and permit by this means an assimilation of the dye before it has had opportunity to accumulate in the flot.

When removing the goods after attaining a desired shade of color, further precaution in manipulation is required to prevent unevenness of coloring, produced by what is technically called *over-dyeing*. This occurs when the material is heaped, still warm and saturated with the liquors of the bath, or when, as yarn, it is hung up in the same condition. An accumulation of the fluids in the lowest portions of the heap or skein takes place with a consequent continuation of their action upon the material. In these parts the shade of color will deepen; the parts will be over-dyed. The difficulty is obviated naturally by rinsing the goods, or, preferably, as giving a richer general effect, by allowing the materials to remain in the bath until it has cooled. Rapid reduction of the temperature by addition of cold water is, however, the usual practice because of its expedition.

In the species of monocolor dyeing, to which remarks have been incident, the coloring matter already prepared is caused to combine with the natural or mordanted fibre. The reaction of the preparation of the dye-stuff may also be

allowed to take place within and upon the fibre; the process is then known as *ingrain dyeing*. The method of itself is not new; indigo, among the oldest of the natural coloring matters, is produced within the fibre, which has absorbed a solution of the reduced dye, by means of oxidation, and aniline black for years has been generated by the same chemical process upon fibre impregnated with aniline chloride. Since the development of the azo-industry, however, ingrain dyeing has assumed special prominence; from this source illustrations will mainly be drawn.

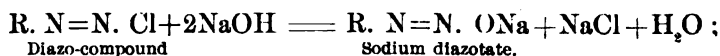
Two principles are represented in the existing practice: the material is impregnated with a compound necessary to the preparation of the coloring matter, and, thus sensitized, is brought into the solution of a developer or reagent still required to generate the dye-stuff; or a coloring matter directly attracted by the fibre is fixed according to ordinary usage, and afterwards, still in combination, is converted by diazotation and coupling into an azo- or disazo-compound, or, by other reactions, undergoes still further transformations, as lake-formation with metallic salts.

The fabric is treated in accordance with the principle first set forth, for example, with an alkaline solution of a phenol, dried, and passed through that of a diazotized base which combines with the phenol to an insoluble azo-compound within the fibre. The principal of the phenolic components used is betanaphthol; applicable bases are, besides the simpler aniline, toluidine, anisidine, phenetidine, certain nitro-derivatives, and the naphthylamines, the more complicated amidoazobenzene and such derivatives of diphenyl as benzidine, tolidine, dianisidine and diphenetidine. Serviceable dyeings, naturally, are only obtained when components are selected with reference to the production of extremely insoluble compounds.

The instability of the diazo-compounds required in the process, necessitating a low temperature during the developing, for a time was a source of inconvenience in operating, and an

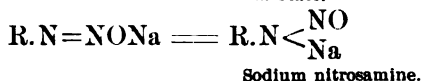
obstacle in the way of a full realization of the otherwise many advantages of the method.

The introduction¹ of simple, stable transformation-products of diazo-compounds, the nitrosamines, by which diazotation and the use of ice are obviated, was, therefore, a progressive innovation eagerly adopted by the dyer. Diazo-compounds, under the influence of alkalis, and usually also of heat, are converted into nitrosamines; from these the original compound is readily regenerated by acidification. The equations will illustrate:

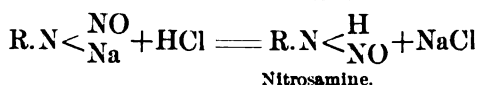


Diazo-compound

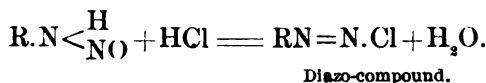
Sodium diazotate.



Sodium nitrosamine.



Nitrosamine.



Diazo-compound.

The nitrosamine is sold by the color-works in the form of a 25 per cent. paste readily soluble in water. Before use, mere solution and acidification are required.

Recently stable, soluble diazo-developers have been produced in other forms. Thereby, for instance, the observation² is utilized that, in presence of an excess of mineral acid, diazo-solutions may be concentrated at a temperature of 45° C. without noteworthy decomposition; the well-known inflammability of such preparations is overcome or greatly reduced by addition, to the solution while concentrating, or afterwards to the dry salt, of alumina, sodium sulphate, etc. Double salts have further proven available in some variety in obviating the inconveniences of what were known but a few years

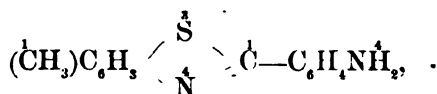
1. Bad. Anil.-u. Sodaf.: *Germ. Pat.*, 81791.

1. *Bad. Anst. u. Bodan. Germ. Pat.*, 61811.
2. *Farbwerke vorm. Meister, Lucius & Brüning: Germ. Pat.* 85387.

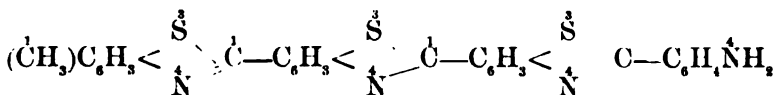
ago as the "ice colors." Thus for colors from diazo- and tetrazo-compounds derived from amidoazo- and diamidoazo- bodies, zinc¹ and, in general, tin-zinc double salts are prepared. Double compounds with nitrobenzene sulphonates² have also been proposed. In addition to these should be mentioned the admixture to diazo-compounds of bisulphates.³ Here the diazotation takes place in concentrated sulphuric acid solution by means of nitrous anhydride; this completed, sufficient neutral sodium sulphate is added to the diazo-solution to convert the excess of acid into bisulphate.

The hydroxyl of the phenol of the fibrazo-color, however generated, is still reactive and interacts with metallic salts, forming lakes. These are characterized by even greater insolubility than the original oxyazo-compound, and have been found remarkably modified in quality in other respects, as in fastness to light, and in color. Copper salts have proven of special value. An instance in point is offered by the compound from betanaphthol and tetrazodianisol chloride. It is a violet of unsatisfactory shade and extreme sensitiveness to light. The copper compound of the dye, *dianisidine blue*,⁴ is a brilliant blue and faster even than indigo to light.

The use of dye-stuffs with direct affinity for the fibre is well illustrated by the behavior of *primuline*, a mixture of the sodium sulphonates of a simpler,



and of a more complicated amidothiazol,



1. Farbw. vorm. Meister, Lucius & Brüning : *Germ. Pats.* 89437 and 94496.

2. Fabriques d. Prod. Chim. d. Thann et d. Mulhouse (Feer), *Germ. Pat.* 88949.

3. Cassella & Co.: *Germ. Pat.* 97933.

4. Farbwerke vormals Meister, Lucius & Brüning : *Germ. Pat.* 80409.

presumably constituted as thus indicated. Directly attracted by both cotton and wool, these materials are easily dyed by it, the color being a pale yellow. By virtue of its free amido-group, it may be transformed by nitrous acid into a diazo-compound capable of various combinations with the well-known phenol and amine components. A series of fine, fast colorations of many shades is derived.

Similarly, certain substantive cotton dyes, containing amido-groups, are diazotized and developed upon the fibre with solutions of phenols and amines with the production of a variety of shades; in general, owing to the complexity of the compounds formed, shades of black are generated. Dyeings derived from *diazotized benzidine* and its analogues paired, in alkaline solution, with the *amidonaphtholsulphonic acid G* (see formula, Proceed., 1898, p. 131), may be cited as instances.

As further illustrating the second principle of ingrain dyeing, mention is made of the development of the *chromotrope colors*, azo-colors derived from a dioxynaphthalenedisulphonic acid, industrially known as chromotrope acid (see formula, Proceed., 1898, p. 132); of the mordant-compounds of combinations of diazotized *nitraniline* and *betanaphthylamine monosulphonic acid 2. 6.*, with *salicylic acid*; and of similar compounds of the *acid (sulphonic) alizarine* colors. The unmodified dyes are all possessed of hydroxyl-groups in varied combination, as such, or as a member of the carboxyl- or sulphonic group. In this feature they resemble the betanaphthol-colors, and also in being strongly modified in properties, especially color, by the action of metallic salts. Here the latter perform the part of developers, as did the diazo-compounds in the first instance. Alum, chromium fluoride, and sodium bichromate are named as among the principally applied developing compounds. The two first mentioned produce lakes varying in color with the metal, while the last acts by oxidation, producing bodies of unknown constitution.

Particularly brilliant effects are obtained in the combina-

tions containing chromotrope acid. They display colors ranging from cochineal red through bordeaux, prune and violet to deepest black.¹ They are further distinguished by great fastness, even to the exacting degree required of successful wool dyes, as which they are chiefly or exclusively used.

Containing the salt-forming carboxyl- or sulphonic group, or both, the original coloring matters are directly fixed by the fibre; in their application, therefore, they are first brought upon the material, as usual for acid dyes, in hot acid bath, and treated simultaneously or in a separate bath with the developer which will yield the shade desired.

The productions of all modifications of the method for developing the coloring matter within the fibre are especially valued for a high degree of fastness to washing and light.

PRINTING OF THE TEXTILE FABRICS.

In the processes of dyeing outlined, there has been application of color to the material as a whole; the object has been to impart uniformity of color. A modification in which color is locally applied, prevented in its formation, or destroyed (frequently with the simultaneous substitution of other colors) upon materials already dyed in monocolor, is the basis of an industry of vast proportions, the printing of the textile fabrics.

The union of fibre and dye-stuff, whether applied to the whole or but part of the fabric, is essentially by the same reactions; the generation of Turkish red, for instance, in the printing of alizarine, is by the formation of the same lime-alumina-fatty-acid lake as in dyeing. The differences entailed arise in the circumstances of its production, are technological differences.

1. *MECHANICAL PROCESS.*

As in dyeing, *the coloring matter* usually is applied in solution when printed. The *solvents* will necessarily depend

1. Friedländer: III, 558; *Germ. Pat.* 69095.

upon the nature of the dye-stuff; among them may be mentioned, besides water, alcohol, acetic acid, acetine, glycerine, ethyl-tartaric, tartaric, oxalic and sulphuric acids, acid sulphates, and ammonia, sodium carbonate, borate and phosphate in solution.

The solution accomplished, it requires adaptation to its purpose by *thickening* to permit the transfer of the color to the material, in the well-known manner by rolls upon which the pattern to be printed is engraved.

Agents to this end are flour, starch, dextrine and various gums. They exert not a little influence upon the process, especially in the later operations of fixing the color and cleansing the printed material, and care is required in their selection. It is of utmost importance, for example, that the prints do not "run" or blur, after the color has been applied.

The prevention of the union of coloring matter and fibre until after the printing has been finished, is a further consideration. As a rule, the reagents already cited as solvents, have the additional property of *restraining the reaction* of the dye-stuff. Acetic acid among the acids is extensively used for the purpose, more especially with the acid and mordant-colors. In the preparation of the latter for printing, the mordant, as before, is made part of the printing fluid; the incorporated restrainer prevents premature lake formation. Or the material is printed with the mordant alone, and, after fixing it according to processes indicated in the discussion of mordants, and the removal of the thickening, is dyed; only the mordanted parts of the material attract the coloring matter. That the progress of the application of the nearly colorless mordanting substances may be visible to the printer, fuchsine and other *sighteners* are embodied in the printing mixture.

Whatever the character of the goods or the dye-stuff, and however the latter may be applied, the color, after printing, is developed and fixed by the process of *steaming*. The goods are brought into specially adapted iron chambers and

there exposed to the action of vapor of water of varying pressure and degree of saturation, the conditions being suited to the colors employed. The solvents and restrainers are evaporated or otherwise desirably transformed, and combination of the fibre with the color becomes possible and is effected. A judicious choice of the several reagents necessitated in preceding operations will appear as a matter of greatest importance to the success of the process when the test of the steam-chests is applied, both in respect to the development of the color and the action of the ingredients of the printing mixture upon the goods. Solvents, for instance, must be readily volatile in the main, and, together with bodies formed during the union, must exert no deleterious influence upon the fibre. Cotton fibre is sensitive to the mineral and fixed organic acids at the temperature of the chambers. Acetic acid, which does not tender the fibre, and acetates are, therefore, used as solvent and mordant respectively when practicable. In the presence of mordants containing other usual acids or of their salts with the color-bases, acetates are added to the printing fluids, and insure neutralization of the injurious acid otherwise set free in the steam-chambers. Woolen and silk fabric, as less sensitive to acids, do not require the same careful avoidance of these reagents. The serviceability of the thickening-agents of the color is also severely tested during the steaming, and, as before stated, are chosen with particular reference to the action of steam under the conditions. It is plain that they must sufficiently resist solution and mechanical loosening if slightly prints are to be obtained.

Following the steaming are the further operations having for their object the more permanent *fixing* and *brightening* of the printed goods. Where the basic colors, to illustrate, have been used upon tannated cotton, the material is passed through a tartar emetic bath. Thereby a compound, antimony-tannin lake is produced with increased fastness of the color to washing. Wool and silk are printed mainly with the acid colors

for which they possess strong direct affinity; special fixing, therefore, becomes unnecessary.

In the use of the mordant-dyes, chiefly with cotton in calico-printing, the goods have undergone a preliminary treatment with turkey-red oil or other soap solution; these fixing-agents, therefore, accomplish their purpose during the steaming, when mordant and dye-stuff have been printed together. If the mordanting precede the application of the color, the goods, after removal from the dye-bath are treated with Turkish red oil and steamed, or, it may be, heated under pressure with soap, sometimes together with tin compounds. As before fatty acids and tin enter the lake already formed during the dyeing. Both in fastness and brilliancy, the prints are favorably affected.

The next operations in printing are the *clearing* and *cleansing*. Beauty of effect is greatly dependent upon the purity of the ground, especially if it be white. To secure this careful, rational washing combined with bleaching in dilute chlorine solution, is made use of.

When dyeing upon printed mordants, ingredients are introduced into the bath to prevent the staining of the parts without impressions. Besides tannic acid, usually also present to participate in the formation of the lake, glue and albuminous substances are found useful. Their action as yet is not understood, although their value is unquestioned.

The *finishing* of the prints is an important operation by which the material is made the more presentable to the purchaser. Starching and drying are the chief operations. The former may be done only on the unprinted side of the goods, or on both sides. In applying the finishing preparation, the material is passed into it and then between rolls for expressing the excess, when the right and wrong side both are starched. If the wrong side alone receive the application, it is made by means of a roll which dips into the starch and comes in contact with the print as it passes over the roll, a scraper, or

“doctor,” of glass or rubber removes a surplus. Passage over steam-heated rolls accomplishes the drying. Softness of feel may be imparted, if required, by addition of oil, soap, wax, glycerine or substances of like effect to the starch. When an exceptionally glossy finish is desirable, calendering is applied.

Remarks relative to the printing of the textile fabrics have touched thus far only upon the affixing of the color to a white ground. The production of patterns in white and colors upon a colored ground, in connection especially with the methods for developing the ground color directly upon the fibre, is, however, one of the most interesting and important phases of the industry. Diversified and beautiful effects are attained as the result of refined scientific observations.

Two general methods are employed. In one, patterns in white or color, known as *discharge styles*, are produced upon a colored ground. The second method impresses the figures before the generation of the ground color; the results are technically classed as *resist styles*.

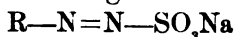
The names suggest the operations: to produce white upon a colored ground, color is destroyed or “discharged” by printing reducing or oxidizing reagents, solvents, etc., in pattern, steaming, washing in acid bath, bleaching, and in general the use of means to decompose or dissolve the coloring matter, remove it or the products of its decomposition, and clarify the white of the exposed fibre. If colors which will resist the action of the discharge, or may be reduced without deep-seated decomposition, be printed with it, it is evident that colored figures will be formed, or may be developed by oxidation upon a colored ground. As discharges for white, the alkaline sulphites, stannous chloride, zinc dust and chlorates, sometimes together with special solvents for the ground-color to aid their action, are mainly employed. Among dye-stuffs incorporated in colored discharges may be named phosphine, methylene blue, the basic triphenylmethane colors with tannin,

the eosine colors, gallocyanine, gallamine blue, paranitraniline red, and dianisidine blue.

The resist modification of the process reserves parts of the material, which are printed with preparations that prevent them from fixing the ground-color in the dye-bath, either mechanically or by solution of the mordant with which the material may have been prepared. Admixed with suitable coloring matters, resists are also made to produce colored figures upon a colored ground. China-clay, barium sulphate, wax, resin, albumen, alkaline citrates, in thickened suspension or solution, act, among others, as resists. In case the ground-color is to be dyed according to the ingrain method for azo-dyes, the goods are first impregnated with the usual naphthol, and, before entering the diazo-developing bath, printed with the desired color so prepared with thickening and reducing agents as to prevent, after fixing by the hot drying plates, the action of the developer on the parts bearing the impression. The resist color, which has been reduced, is brought out by oxidation (chroming) after the formation of the ground color.

2. PHOTOGRAPHIC PROCESS.

Diazosulphonates of the general formula,



have the curious property, when mixed in molecular quantities with phenolates and amine salts, and exposed to light, of combining to azo-coloring matters.¹ *Primuline* when diazotized is also sensitive under the same influence, the diazo-compound being decomposed.² These observations are the basis of the diazo-type process for colored photographic printing both upon the textile fabrics and paper.

In accordance with the first, the material is impregnated with the required ingredients for the production of a desired

1. A. Feer: *Germ. Pat.* 53455.

2. Green, Cross & Bevan: *Germ. Pat.* 56606.

azo-color, dried, and exposed under a negative or pattern to sun or electric light. Under the transparent portions of the negative, or in the unprotected parts of the pattern, the colored compound is developed; under the opaque parts, the material is unaffected. Washing in very dilute acid solution fixes the print.

When primuline is used, its application to the material is made as diazo-compound, or directly as such by dyeing, being afterward sensitized by diazotation in the dark. The exposure, for which the moist or dried material is then ready, is followed by immersion in the developer, a solution of a selected amine or phenol. Where light has not penetrated to the sensitized material, the usual formation of an azo-coloring matter ensues. The exposed regions are incapacitated for combination. Transparencies in color upon glass coated with gelatine may also be produced by the method.

The color of the prints, naturally, is varied at will, as implied, by a choice of both components, in the first instance; in the second, by changing the amine or phenol. The possibility of attractive decorative applications of both modifications of the diazo-type process is evident; as yet, however, the prints obtainable are merely interesting curiosities.

MISCELLANEOUS SUBORDINATE APPLICATIONS.

Related in principle to the dyeing and printing of the textile fibres with the artificial coloring matters, is their application in the *dyeing of hair, horn, leather, feathers and straw*.

In the same category is found the highly interesting, though less extensive, application in *histological research*. By their selective action upon the substances of the elementary tissues of vegetable and animal organisms, being attracted and dyed by one and again behaving with indifference to others, the coloring matters have revealed morphological details otherwise invisible in the microscopic examination of such

objects. The allusion recalls the invaluable aid of the artificial colors in differentiating the structural features of the lower forms of life. In contributing to the advance of knowledge of the pathogenic microorganisms, the coloring matters perform an important part as combatants of the diseases of mankind.

The *preparation of pigments* employed in wall-paper printing, lithography and water-color- and oil-painting is also in some of its modifications a species of dyeing, and again, is purely of the nature of a lake-formation. When the basic colors in solution, for example, are boiled with green earth, infusorial earth, and the like, these *substrata*, as they are denominated, are dyed; the color-bases enter in part into firm chemical combination with certain of their constituents, in this instance, silicic acid. The action of eosine and its relatives upon lead salts with which they yield brilliant pigments, or of triamidotriphenylmethane dyes upon tannin, with the same object, is one of double decomposition; a lead salt of the color-acid or a tannate of the color-base is formed. The substratum present in no degree participates in the reaction; it is a mechanical admixture.

Further uses more or less allied in principle are the *coloring of paper pulp*, the *staining and colored-glazing of paper*, the *coloring of confectionery, food products*, and the *manufacture of inks and colored varnishes*. Only a passing mention can be given them.

Frequent reference has been necessary to an essential quality of successful colors in their relation to the textile fibres, that of resisting the bleaching action of light. An application of much interest and dependent upon an extreme sensitiveness of certain coloring matters to light, a reversal of the successful condition, deserves more extended notice.

The decomposition by sunlight of the natural organic colors has long been a well-known phenomenon, dating in its

1. Compare resume of Guehm u. Röthell quoted in the discussion of the theories relative to dyeing.

general recognition from remote antiquity. To a knowledge of the determining conditions important contributions were made early in the present century, notably by Chevreul. In the absence of air the colorations by certain vegetable colors were found by him to be stable to the action of light, while the reverse was markedly true in its presence. The accelerative influence of moisture, especially, was pointed out. Much later, in 1842, an important discovery was made by the celebrated Herschel in his study of the relation of light to the bleaching of the coloring matter of flowers. It was observed that, for a given case, the rate of decomposition in light of varying quality was greatest for the color complementary to that of the coloring matter, that is, for the color absorbed. This observation was a confirmation of the general law, first enunciated by Draper in 1841, which states that *only those rays of light which are absorbed by a substance chemically act upon it.*

In the course of studies upon the action of the solar spectrum upon films containing the haloid salts of silver, experiments were conducted by the late eminent photo-chemist, Prof. H. W. Vogel, with a brand of silver bromide dry-plate then upon the market, and stained, with the object of preventing reflection within the glass plate carrying the film, by a yellow coloring matter of unknown composition. The plate exhibited increased sensitiveness to the green rays of the spectrum. The remarkable phenomenon was attributed, and demonstrated to be due, to the presence of the coloring matter. Being yellow in white light, the complementary green rays were absorbed, causing intensified effect in the photograph of the green portion of the solar spectrum.¹

A comprehensive study of the subject was immediately undertaken by Vogel and later extended by others, prominently Eder; numerous artificial dye-stuffs were discovered

1. H. W. Vogel. *Handb. d. Photographie*, I., 304.

by examination of the absorption spectra of their solution to evidence a similar property in other parts of the spectrum.

In accordance with the observations made by him at that time, 1873, Vogel conceived the idea of utilizing the discovery in improving the general sensitiveness of the photographic plates then in use. The ordinary process for the preparation of films sensitive to light by means of the silver salts in various media (collodion, gelatine) results in a film toward which mainly violet, blue, and blue green rays are actinic; green, green yellow, yellow and red portions of the spectrum are but slightly or not all absorbed. In the photograph of objects emitting rays of varying quality, suppose, for illustration, the spectrum of white light, the colors first mentioned all appear as white; green, yellow and red, on the other hand, are reproduced almost equally dark. Thus, shades of color, bright to the eye, are reproduced in unnaturally dark tones, and *vice versa*; the result in general is a false relative effect.

Following the suggestions of the facts presented, sensitizing the photographic plate for that portion of the spectrum inactinic for the usual bromide-emulsion plates and with reference to the object to be photographed, the disturbing effect may be largely corrected. The materials at hand, singly and in combinations, enable augmenting the sensitiveness of the plate for nearly all parts of the spectrum. Important among the sensitizers are the coloring matters erythrosine, cyanine, quinoline red, and azaline, a mixture of cyanine and quinoline red; lesser in utility are fuchsine, eosine, naphthalene red, and aldehyde green. In selecting a sensitizer it is not enough to consider its absorption spectrum alone, for only those colors are active in this capacity, which are fugitive to light. A successful color for red besides displaying a strong absorption for red rays must undergo decomposition, be bleached by red light; otherwise it will prove inactive upon the photographic plate. In general, *the more rapidly a dye-stuff is chemically*



MICHEL EUGÈNE CHEVREUL.



HERMANN WILHELM VOGEL.



TÖLTZ.

REPRODUCED FROM A PHOTOGRAPH BY J. B. OBERNETTER, OF MUNICH, ON THE *USUAL DRY PLATE*. FROM DAVID AND SKOLIK'S "ORTHOGRAPHISCHE PHOTOGRAPHIE," BY SPECIAL PERMISSION OF THE PUBLISHING HOUSE OF WILHELM KNAPP, HALLE A. S., GERMANY.



Tölz.

REPRODUCED FROM A PHOTOGRAPH BY J. B. OBERNETTER, OF MUNICH, ON AN *ERYTHROSINE PLATE* WITH THE USE OF A *PALE YELLOW SCREEN*; CONDITIONS, EXCEPT SLIGHTLY LONGER EXPOSURE, THE SAME AS ABOVE. FROM DAVID AND SKOLIK'S "ORTHOGRAPHISCHE PHOTOGRAPHIE,"¹¹ BY SPECIAL PERMISSION OF THE PUBLISHING HOUSE OF WILHELM KNAPP, HALLE A. S., GERMANY.



FIG. 20.

ENGRAVED FROM A PHOTOGRAPH OF A TRI-COLOR REPRODUCTION IN NATURAL COLORS, BY THE *USUAL PROCESS*. SPECIALLY EXECUTED FOR THESE LECTURES BY THE F. A. RINGLER Co., NEW YORK.



FIG. 21.

ENGRAVED FROM A PHOTOGRAPH OF A TRI-COLOR REPRODUCTION IN NATURAL COLORS, ON AN *AZALINE PLATE*. CONDITIONS IN PHOTOGRAPHING IN OTHER RESPECTS UNIFORM WITH THOSE PRODUCING FIG. 20. WORK EXECUTED BY THE F. A. RINGLER Co., NEW YORK.

*changed by light, the better it acts as a sensitizer of the silver salts for the light which it absorbs.*¹

These discoveries which have opened a new epoch in the science and practice of the photography of color, are the basis, as well known, of *orthochromatic photography*. In the reproduction of paintings, in the photography of subjects of most varied description, in which bright colors abound, the effects attained by the use of orthochromatic plates are remarkable in correctness of tones, and correspondingly gratifying to the eye. The illustrations reproducing photographs of an engraving in color and a landscape taken with the usual dry plates and again under the same conditions with plates sensitized for color may be found of interest, although doubtless in kind are not unfamiliar.

Advancing beyond the simpler reproduction of color in relative correctness of tones, orthochromatic photography in combination with photo-engraving has enabled highly pleasing approximations in the depiction of actual color. The reference is to the *tri-color reproductions in natural colors*.

For the execution of this process, three photographic plates sensitized as perfectly as the means extant permit for the rays of the red end, those of the middle region and the blue and violet portions of the spectrum are exposed successively to the subject to be depicted, the light for the plate sensitized for red and the middle region being filtered through spectroscopically adjusted absorbents for the violet, blue and blue green rays which are strongly absorbed by the usual bromide, or bromiodide plates. The plate for the blue and violet portion being required to absorb the violet, blue and blue green rays, is the ordinary not specially sensitized plate without filter. Three negatives are developed, and from each a photo-engraving plate prepared. These are printed in color, one over the other, in the order of yellow, red and blue; *the color applied for the separate impressions possesses*

1. H. W. Vogel. *Germ. Pat.* 19306.

*an absorption spectrum the same as, or very similar to, that of the coloring matter used as a sensitizer upon the original orthochromatic plate.*¹ The discovery of this scientifically correct principle for the selection of the printing-colors was likewise made by Vogel. The accompanying reproduction from nature handsomely illustrates the work of the process.

D. DISTRIBUTION AND EXTENT OF THE COAL-TAR COLOR-INDUSTRY.

In conformance with circumstantial limitations, this review, of necessity, has contemplated a discussion of merely the *more important* series of artificial organic dye-stuffs. Therefore silence has prevailed with respect to a large number of substances of the same general category. Among others are the scientifically interesting and practically important thiazines, oxazines, the large class of azines comprehending the safranines and indulines, and the compounds of the indigo group. This is with reluctance, especially as concerns the latter; the fascinating account of the investigation of the constitution of these bodies by Adolph v. Baeyer, which culminated in establishing their molecular structure, and the triumphant synthesis of indigo, after seventeen years' persistent effort, comprises a proud chapter in the history of chemical research.

However, it is but reiteration to state that the endeavor has not been, and could not be, to deal even in a moderate measure exhaustively with the subject; it has rather been *to emphasize the scientific basis and suggest the practice of a great chemical industry.*

This thus far has had, in a sense, a subjective treatment; it has seemed appropriate in conclusion to objectively consider the industry, to develop a notion of its distribution and extent. No attempt will be made to discuss the subject in full statistical detail, nor could it be successfully, even if otherwise in

1. H. W. Vogel: *Handb. d. Photographie*, II. pp 222-240.

place; the data are scattered, difficult of access and by no means complete. From various sources it has been possible to gather sufficient material to convey a general conception of the magnitude of the industry, and thereby be in full accord with the purpose.

The enterprises comprising the coal-tar distillation and the manufacture of the organic coloring matters are mainly distributed throughout those European countries which have energetically joined in the march of progress led by scientific methods, and have also found footing upon American soil.

The production of the *raw materials* for the manufacture of dye-stuffs has attained its greatest development in England; Germany, France and Switzerland follow in the order named. In the United States, in comparison, the manufacture is almost insignificant.

To state, with approximation even, the present amount of capital invested in the industry is scarcely possible. Indirectly to the point and in evidence of extensive investment in the tar-distillation is the fact¹ that in 1886 the gas-factories of Great Britain represented a capital of \$350 000 000. The total yield of tar for 1890 was about 860 000 tons;² the larger factories produced, in round numbers, tar to the amount of 500 000 tons, of which at most 94 per cent. were distilled. The German output for the same year was about 100 000 tons; the amount is steadily increasing, besides through the growth of the demand for illuminating gas, by the introduction of by-product coke-ovens. The production in other European countries aggregated probably 320 000 tons.³ The United

1. Lunge: *Industrie d. Steinkohlentheers, etc.*, 3te Aufl., p. 12; quoting Wanklyn.

2. Ibid: Based upon an estimate by Levenstein for 1886 and allowing an increase in yearly production of 5 per cent., and upon that by Wilton, director of the great Beckton tar-distilleries, for 1885, with the same increment.

3. The estimate is deduced in part from the German production, already given for 1890, and its relation to that of France, Belgium and Holland, shown in a table of the work of Lunge, just referred to, p. 11; the calculation indicates a total for these countries of about 170 000 tons. The product of all other European states may be conservatively estimated at 150 000 tons.

States, in the years about 1886, produced 120 000 tons;¹ the output in 1890 was probably 140 000. These statistics and estimates denote for the time and countries considered, practically for the world, a total production of more than 1 400 000 tons of tar. The yield for 1898 doubtless approximated 2 000 000 tons.

Data regarding the production and worth of benzene and anthracene, the most valuable constituents of the tar, will directly contribute to a conception of the extent of the tar-distillation.

The total yield of commercial *benzene* and *toluene* from the tar of European countries is estimated by Caro² to have been in 1890 about 30 000 000 pounds with an approximate value of \$2 925 000. Nearly 19 000 000 of this quantity were the product of the English distilleries, somewhat less than 8 000 000 were produced in Germany (more than one-half as coke-oven by-product), and the rest was distilled in France, Belgium, Holland and Austria.

The German production in 1896, presumably well over 10 000 000 pounds, was a portion of the products of 30-35 distilleries;³ among them are five or six large establishments employing 80-100 men for every 10 000 tons of tar distilled yearly. In each are engaged three to four scientifically educated chemists.⁴

Some 15 of the German firms are also engaged in the manufacture of *anthracene*. England, however, largely supplies the markets of the world with this substance. In 1888⁵ the total quantity of pure material manufactured was estimated at 5 500 000 pounds, representing a value of nearly \$1 500 000. Seven-eighths of the yield were prepared in English works:

1. Lunge: *Steinkohlentheer*, etc., 3te Aufl. p. 13.
2. Caro: *Ueber d. Entw. d. Theerfarben-Ind.*, Ber. d. deutsch. chem. Ges. 25c, 974.
3. Wenzel: *Addressbuch d. chem. Industrie d. deutsch. Reichs*.
4. Private communication of my friend, Dr. R. Weissgerber, chemist in the tar-distillery of Erkner, near Berlin, Germ.
5. Schultz: *Chemie d. Steinkohlentheers*, II., 597.

the rest was manufactured in Germany. Plus an increment of perhaps 15 per cent., the figures deduced would not exaggerate the status of the present production. More than 85 per cent. are consumed by the alizarine-works of Germany.

The manufacture of *coloring matters* as their exclusive object, with several exceptions, was conducted in 1896 by 50 odd factories;¹ these were divided among the centers of manufacture as follows: Germany, 23; England, 12; France, 7; Switzerland, 7; United States, 3; Belgium, 2; Holland and Italy each, 1.

No means are extant for the compilation of figures showing the total capital invested in these enterprises; from available sources a limited statement with regard to only the more extensive German plants has been prepared. Seven of the total of 23 have an aggregate capital of \$16 000 000² and 13 000 employes;³ three of the largest firms are represented by a capital, in round numbers, of \$10 125 000 and about 9 750 employes, including more than 250 chemists, graduates of the renowned scientific institutions of the country.

The industry of the United States is operated by a capital liberally estimated at \$1 000 000.⁴

Nine-tenths of the entire output of coloring matters, from all countries, are produced by Germany. In 1891, the export of colors consisted of 8 600 tons of aniline, azo- and resorcin colors, and 8 168 tons of alizarine, valued respectively at \$11 067 250 and \$3 226 500.⁵

As a summary statement of the commercial significance of

1. Schultz u. Julius: *Tabellar. Uebersicht d. Künstl. organ. Farbstoffe.*

3. Wenzel: *Adressbuch, etc.*

2. The relative efficiency of money in Germany and the United States being 3 or 4 to 1 these valuations, translations of statements in "marks," should properly be trebled or quadrupled to convey in the United States a correct impression of the worth of the investments under discussion; "one mark" has been translated "25 cents," its approximate gold value.

4. Kindly communicated by Dr. Geo. A. Prochazka, director of the Central Dye-Stuff and Chemical Co., Newark, N. J.

5. O. N. Witt u. Otto Ernst: *Amtl. Ber. über d. Weltausstellung in Chicago, 1893—Chem. Industrie*, p. 64.

the industries based upon the tar-distillates, greater accuracy cannot be attained than is contained in the admittedly approximate estimate of Dr. Heinrich Caro long the scientific director of the Badische Anilin- u. Sodafabrik. In accordance with this, their annual contribution to the wealth of the world reaches the formidable sum of about \$25 000 000; two-thirds of this amount are Germany's portion; Switzerland, England and France rank next in the order named.

It will be remembered that the manufacture of the coal-tar colors, as well as the tar-distillation, had its origin in England, dating from the discovery of Perkin's violet; in France, the fuchsine manufacture developed into a great monopoly; simultaneously with Germany, England entered upon the production of artificial alizarine; the color-works of England, France and Germany engaged almost at the same time in the preparation of the azo-dyes; and, in every branch of the industry, Switzerland was early a successful competitor, at present holding second place in the list of rival nations, although at one time in proportion to its population occupying the position of first importance.

The facts cited depict the towering supremacy of Germany's interests, an industrial condition deserving the close attention of the social scientist and industry universally. The predominating influence in its creation, however modified circumstantially and by other national traits, has been, as admitted by qualified observers of whatever nationality, the zeal with which pure chemical science has been fostered in Germany. The twenty German universities and half as many polytechnic institutes for years have enjoyed world-wide distinction as the chief seats of chemical investigation and learning. These institutions have been the scene of the work of the master minds of the science, numerically and in eminence not paralleled in its history in any other country; to-day, this position is undisputed.

EMINENT SCIENTISTS WHOSE CHEMICAL RESEARCHES (MENTIONED IN THIS COURSE LECTURES) HAVE CONTRIBUTED INFLUENTIALLY OR MORE DIRECTLY TO THE DEVELOPMENT OF THE COAL-TAR COLORS.



JUSTUS V. LIEBIG.



AUGUST WILHELM V. HOFMANN.



WILLIAM HENRY PERKIN.



AUGUST FRIEDRICH KEKULE.



ADOLPH V. BAEYER.



HEINRICH CARO.



CARL GRAEBE.



EMIL FISCHER.



CARL SCHORLEMMER.



CARL LIEBERMANN.



J. PETER GRIESS.



OTTO N. WITT.



RUDOLPH NIETZKI.

A thoroughly equipped profession in all periods of the industrial evolution of the nation has, therefore, been at hand, not only to aid in establishing industry, but also to accelerate and guide in its future expansion. To no department of chemical industry does this so pertinently apply as to that of the manufacture of the coal-tar colors, intimately identified in its progress with the development of organic chemistry. Researches in this branch of the science were early and energetically prosecuted by Liebig, and since by his school, with persistent enthusiasm which has spread with varying intensity to many foreign centers of chemical investigation.

These conditions created by the national character have produced a profession of broad and thorough education, and cause those of its members who practice in the field of industrial chemistry to be constantly alive to the absolute importance of the furtherance of pure science, keep them in touch with it, and lead to the application of its methods and observations in conducting the affairs of industry. The constant contact by this means of pure and applied science is the practical expression of the leading, original factor of the progressiveness and supremacy of Germany's chemical industry. The magnificent result of its influence, especially as manifested in the manufacture of the artificial organic coloring matters, is pointed to with a most justifiable pride by her men of scientific culture as a *national* industry,¹ and should be a strikingly impressive object-lesson to all countries whose industrial methods are dominated in the face of scientific information, in whatever degree, by a stubborn conservatism known tritely as "the rule of thumb."

An informal discussion followed the reading of the paper.

On motion of Mr. Garrigues, the thanks of the Section were extended to Dr. Johnson for the interesting and instructive series of papers which had been presented by him to the Section.

The meeting adjourned at 10 : 30 P. M.

A. G. McKENNA,

Secretary C. S.

1. Caro: *Ueber d. Entw. d. Theerfarben-Ind.*, Ber. d. deutsch. chem. Ges. 25c, 1101.

CORRECTIONS AND ADDITIONS APPLYING TO PRECEDING PAPERS.

PROCEEDINGS FOR 1897.

Page 508, thirteenth line from top, read "has" instead of "have."

Page 522, add to first line: "In the English works nitration is conducted with much larger charges, as much as 1 000 to nearly 2 000 pounds of benzene being used."

Page 523, fourth line from bottom, read "by" instead of "with."

Page 524, eighth line from the top, insert "is" after "steam."

Page 524, tenth line from the bottom, read "other" instead of "others."

Page 525, in the formula of orthotolidine the methyl-groups (CH_3) should appear in ortho-position to the amido-groups (NH_2), not in meta-position as shown.

Page 526, second line from bottom read "alphanaphthylamine" instead of "alphanaphtylamine."

Page 527, last line, insert "of" after "medium."

Page 528, fifteenth line from bottom, read " $\text{C}_6\text{H}_5\text{CHCl}_2$ " instead of " $\text{C}_6\text{H}_5\text{CH}_2\text{Cl}$."

Page 529, sixth line from bottom read "admixture" instead of "adhesion."

PROCEEDINGS FOR 1898.

Page 103, eighth line from top, read "researches" instead of "reseaches."

Page 109, fourth line from top, read after "triamidotriphenylmethane", "The latter is also directly produced by the use of paraamidobenzaldehyde."

Page 111, fifth line from bottom, read "develops" instead of "developes."

Page 111, tenth line from top, read "derivative" instead of "derivatative."

Page 113, tenth line from top, insert "etc." after "diphenylmethanes"; fourth line from bottom, read "diamido-diphenylmethane" instead of "diphenylmethane."

Page 114, seventh line from bottom, read "zinc" instead of "zine"; eighth line from bottom, read "repeatedly" instead of "repeately."

Page 118, add after last line: "The oxidizer is a mixture of cupric salt (sulphate or chloride) and phenol, to which a large quantity of common salt is added for dilution. The action of the phenol, by which the yield is much improved, is not understood."

Page 120, eleventh line from top, read "their" instead of "its."

Page 127, eleventh line from top, read "naphthols" instead of "naptols."

Page 128, eighth line from bottom, read "in what is generally an essential" instead of "an essential"; first line read "fixing" instead of "fix."

Page 129, twelfth line from bottom, read "from" instead of "of."

Page 131, bottom of page, middle formula should be named "G-acid," not "Y-acid."

Page 132, third line from bottom, read "tetrazoditolyl chloride" instead of "diazoorthotolidine"; top, formula reversed.

Page 133, ninth line from bottom, read "ditolyl" instead of "tolidine"; eleventh from bottom, read "tetrazoditolyl" instead of "diazotolidine."

Page 135, last line, read "the" instead of "certain."

Page 138, fourth and sixth lines from bottom, read instead of "aniline" and "an aniline-rest," "a benzene-rest" and "the rest of a simple benzene derivative."

Page 188, after last line, read fifth line of page 189.

Page 206, under last formula, read "Anilineazometa-phenylenediamine" instead of "Phenylazometaphenylene-diamine."

The terms "naphthalene," "naphthol," "naphthylamine," "phthalic," etc., have inadvertently been allowed to appear as "naphthalene," etc., (following the German orthography); "alizerine" should be read "alizarine." "Hydrochloride," in such names as "aniline hydrochloride," "rosaniline hydrochloride," etc., has been shortened to "chloride."

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA,

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The one hundred and ninety-third regular meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the Society's House, 410 Penn Avenue, Pittsburg, Pa., Tuesday evening, March 21, 1899.

The meeting was called to order by the President, Mr. Harry J. Lewis, at 8:35 o'clock, forty-three members and visitors being present.

The minutes of the preceding meeting were read by the Secretary, and, after a motion was passed to incorporate in them the discussion on the Smoke Committee, they were approved.

For the Board of Directors, the following applicants were reported as passed and to be voted for at the next regular meeting :

WILLIAM AHLEN,	-	Chief Draughtsman Duquesne Steel Works and Blast Furnaces, Duquesne, Pa.
CARL B. AUEL,	- -	Engineer, With Westinghouse Air Brake Co., Amber Club, E. E., Pittsburg, Pa.
CHARLES H. BRADLEY, JR.,	Manager,	C. H. Bradley, Jr. & Co., Engineers, 58 Vandergrift Building, E. E., Pittsburg, Pa.
RUNHARDT DAAE,	-	Draughtsman, With Julian Kennedy, 3 Highland Place, E. E., Pittsburg, Pa.
GEORGE W. KNOTTS,	-	Mechanical Engineer Care Lincoln Foundry Co., Butler and 60th street, Pittsburgh, Pa.
FRANK S. LOEB,	- -	Metallurgist and Assistant Superintendent, Duquesne Reduction Co., Pittsburg, Pa.
ROBERT McLAUGHLIN,		Draughtsman, With Westinghouse Machine Co., 318 St. Clair St., Pittsburg, Pa.
HENRY OTTO,	- -	Master Mechanic To Shoenberger Steel Co., Pittsburg, Pa.
WM. O. RENKIN,	- -	Mechanical Draughtsman, With Pittsburg Plate Glass Co., 5 Fulton Street, Allegheny, Pa.

The following gentlemen were balloted for and duly elected to membership :

JAMES BONAR, - -	Mechanical Engineer and Manager, James Bonar & Co., 1216 Carnegie Building, Pittsburg, Pa.
JOSEPH FAWELL, - -	Chief Mechanical Engineer Mackintosh, Hemphill & Co., Pittsburg, Pa.
MICHAEL GREENWOOD,	Agent For Laidlaw Dunn Gordon Co., Carnegie Building, Pittsburg, Pa.
ARTHUR HERSCHMANN,	With Julian Kennedy, Smith Bldg., Pittsburg, Pa.
REES JAMES, - - -	Superintendent Open Hearth Department, The Carnegie Steel Co., Ltd., Homestead Works, Munhall, Pa.
I. WALTER JENKS, -	Superintendent, LaBelle Steel Works, Allegheny, Pa.
JOHN W. PARKER, -	Chief Inspector, The Carnegie Steel Co., Ltd., Homestead Works, Munhall, Pa.
HENRY B. PRATHER, -	Mechanical Engineer and Manager Pittsburgh Office—The American Stoker Co., 1202 Carnegie Bldg., Pittsburg, Pa.
J. E. SCHLIEPER, - -	Mechanical Engineer and Manager of the Pittsburg Feed Water Heater Co., 1216 Carnegie Building, Pittsburg, Pa.
J. E. SCHWAB, - -	General Superintendent, Duquesne Steel Works and Blast Furnaces, Duquesne, Pa.
LOREN H. TURNER, -	Superintendent of Motive Power and Equipment of the Pittsburg & Lake Erie R. R., 61 Maple Terrace, Pittsburg, Pa.

For the Committee on the Abatement of Smoke Nuisance, Prof. Fessenden reported as follows : "A meeting was held at which the following gentlemen were present : Messrs. Hyde, Fitzgerald, Scott and Fessenden.

"It was voted that Prof. Fessenden see the Chamber of Commerce and communicate to them the state of affairs at the present time. It was also voted that a letter be sent to Mr. Bigelow thanking him for his action, a letter having been received from him, as follows:

“March 1, 1899.

“ ‘PROF. REGINALD A. FESSENDEN,

“ ‘City.

“ ‘DEAR SIR: Referring to our conversation of to-day, I will be pleased to coöperate with the Committee appointed by the Engineers’ Society of Western Pennsylvania for the abatement of smoke in Pittsburgh. I have directed our Smoke Inspector, Mr. James J. Brennan, to render you all assistance in his power in the way of furnishing data of plants within the city limits.

“ ‘I will be pleased also to approve and adopt the rating of boilers approved by the Engineers’ Society.

“ ‘Very respectfully,

“ ‘EDWARD M. BIGELOW.

“ ‘*Director Department of Public Works.*’

“ ‘Some further statement was made by Mr. Bigelow, personally, which we also communicated to the Committee, but which it is not considered necessary to make public at present.’”

The following motion was passed: “ ‘Resolved, That in the resolution passed in February meeting, directing the Smoke Committee of the Engineers’ Society to report direct to the Society, and that they should not form part of the joint committee, no discourtesy was intended to the Chamber of Commerce or the Civic Club.’”

For the Power Committee, Mr. Fisher reported that their report was to have been read at the last meeting, but that there was no opportunity on account of the discussion of the Smoke Committee. The report will be printed, but not read before the Society.

Mr. Bole made the following motion:

“ ‘Resolved, That a committee of three, to be known as the Finance Committee, be appointed by the Chair, whose duty it shall be to solicit subscriptions to the funds of the Society.’” Motion carried.

The paper of the evening on the “Use, Design, and Manufacture of Ornamental Iron Work,” by Mr. Chester B. Albree, was then read.

✓ THE USE, DESIGN AND MANUFACTURE OF IRON IN ORNAMENT.

BY CHESTER B. ALBREE.

It was suggested by the Programme Committee, that, as a change from the regular order of engineering topics, a paper on this subject might be of interest to the members.

Iron enters so largely into our modern construction that the question of its proper applications from an aesthetic point of view, as well as from the engineering status, is an important one.

As knowledge in general is mainly derived from precedents and a proper selection of the good from the bad experiences of the past, it would seem best, in order to comprehensively understand our subject, to see in what ways iron has been used ; how it was worked and its aesthetic treatment in decorative work.

Iron was known in the very distant past, early hieroglyphic records indicating its use in India-China and Western Asia at least one thousand years B. C.

It was then considered almost on a par with the precious metals in value, as in the year 900 B. C., part of the treasure captured at Damascus by the Assyrians consisted of 5,000 talents of iron. A Jewish talent was 113 lbs. 10 oz. Troy.

In classic times its use was fairly common in the Roman and Grecian empires. In various museums of Europe are to be seen pieces of window guards, andirons, rings and shackles, lamps and other household utensils, as well as weapons and armor. On the board are some sketches of a few of these early pieces, copied from I. Starkie Gardner's excellent book on "Iron Work," published by sanction of the South Kensington Museum, London, to which I am indebted for much information regarding the subject.

In the museum at Pompeii may be seen a great variety of objects of iron, recovered from the ruins. Notable among these are some small window frames, containing glass lights. As is well known; the art of making window glass practically became extinct for centuries after the destruction of that city, and to find, amid the wreck of that enlightened community, iron sash with glass lights, is indeed a reminder of the old saying, "There is nothing new under the sun," for to-day we find the same thing in use in our own magnificent new court house.

The fabrication of iron into weapons, offensive and defensive, has continued from the first. Fine specimens of helmets, shields, swords, spears and other weapons are found in many museums, and were it not for the unfortunate quality of iron to oxidize and rust away, we would undoubtedly have many more, as we have of the articles in the more durable metals—gold, silver and bronze.

During the dark ages, the art of working iron nearly disappeared, and not until about the 8th century do we again find it coming into ordinary use. The Gauls, Goths, Britons and Norsemen, having large deposits of rich ores and quantities of wood for fuel, reclaimed the art, in order to provide themselves with weapons for the hunt and for their continual warfare with each other. It is not within the province of this paper to enter into a discussion of the history of iron metallurgy, but simply to note that in these early forges out in the woods they succeeded in making quite pure blooms, at first entirely by hand manipulation, later by the aid of trip-hammers, which better worked out the slag.

The product of these Catalan forges and bloomeries was usually in the form of rough bars or chunks, which had to be worked down on the smith's anvil to the desired shapes. The superior qualities of iron for other purposes than weapons were appreciated, and its employment for hinges, locks, chains, window guards, port cullis gates and various

utensils, grew steadily as civilization gradually replaced barbarism.

On the board are some sketches of this earlier work, which, you will notice, was meant for use and not for ornament. The continued progression of civilization brought in its train the desire to beautify and adorn.

Scrolls were added to their hinges, andirons were wrought into grotesque shapes. Strong treasure chests, with elaborately decorated hinges, straps and locks found place in their castles, and we find, from the 10th century onward, the feeling for beauty increasing with the growth of wealth and the skill of the smith keeping pace.

The smith of those days was generally a serf—almost a slave to the reigning lord or baron. His time was his master's, and, as the noble robber barons controlled nearly all the wealth of the land, and were mightily proud of their picturesque strongholds, they would employ the smiths for months, or even years, on a single piece of work that would add beauty and strength to their domain. Hence we can understand better how such wonderful work as is shown in the photographs you see came into existence.

Notice that the keys, locks, knockers and other small articles, are really more like jewelers' work, in their wealth of repousse and sculptured decoration, inlay and engraving, than like products of a smithy. The church vied with the Barons in wealth, and spent enormous sums in the building of cathedrals and monastical establishments, and in most of them exist to-day, wonderful grills, shrines, altar railings and other features of iron calling for bolder design and larger work than the Schmiedeseisen or lock work of the castles. You will notice the extreme difficulty encountered in the welding, interlacing, banding and decoration of some of these masterpieces. With all our modern appliances for rapidly and easily working iron, we see no way to accomplish some of the results they attained, except by hand work, with time left out of the question.

The use of iron for grills, gates, ecclesiastical purposes, etc., spread all over Europe, each country stamping its work with its own individuality. Noticeable among the different styles was the Austrian work, Fig. 1, in which interlacked round bars,



FIG. 1.—AUSTRIAN WORK OF SIXTEENTH CENTURY.

in peculiar concentric forms, varied with scrolls, relieved by flat plate, leaf and griffin designs, often gilded or colored, are very prominent. The general design is typically illustrated by the railing or guard around Maximilian's tomb, at Innsbruck. In Italy, purer forms were used, the trefoil, quatrefoil and cinquefoil, combined with C and S-shaped scrolls, predominating. Leaf work was little used. A good example of Italian work is shown in Fig. 3. But to France we owe, per-

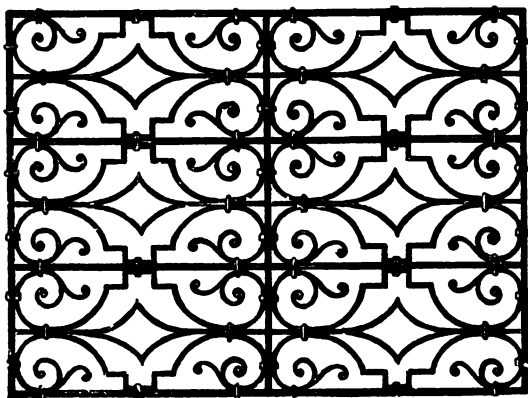


FIG. 3.—ITALIAN STYLE.

haps, the finest examples of wrought iron work. The grace and beauty of design, pure and simple, with the correct use of repousse work, and solid forged ornament, is typified in the Renaissance work of the 16th and 17th centuries, a style well shown in Fig. 4. German work of this period, while



FIG. 4.—FRENCH RENAISSANCE.

showing wonderful technical skill, had become so replete with detailed and elaborated ornament, as to lose all its original character, as may be seen by inspection of the oval panel shown in Fig. 2. The French is a delight to behold



FIG. 2.—ELABORATE GERMAN STYLE.

in its true expression of the æsthetic value of ornament rightly applied. It would be easy to occupy the entire evening with a discussion of the different styles of iron work, taking up the comparative artistic qualities of Renaissance, Rococo, Baroque, Gothic, etc., but that would be more suitable for an architectural society than for ours, so I will but allude to a few later phases of iron design, before bringing to your attention the actual methods of working the iron in use at various epochs. In America, we had a period in which iron design was exceptionally good, known as the Colonial period. It was, as regards architecture, an adaptation of classical lines, to our own domestic and public buildings. It was conspicuous

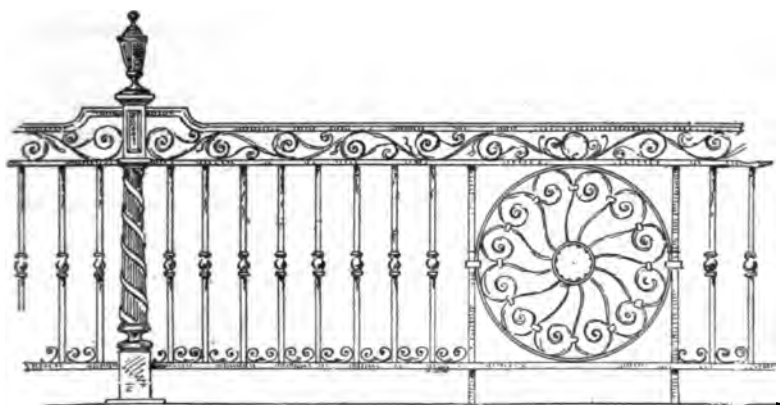


FIG. 5.—COLONIAL STYLE.

for its simplicity and pureness of general design, and of detailed decoration and easy adaptability to various classes of buildings: Good examples are seen in Old Independence Hall, in Philadelphia, the old State House, and numerous other public buildings in Boston, and hosts of residences throughout the colonies. The development as regards iron work, was along the line of straight vertical rods with panels at intervals, with

simple scroll, circle and oval decorations often accompanied by friezes or bands of scroll work—running in free lines, but with frequent repetition. A typical design is shown in Fig. 5. The style was good, and is to-day as popular, and deservedly so, as any of the regular schools.

About the end of the 18th century and beginning of the 19th, when this country was in a rather impoverished condition, after a long war, and when the minds of people were otherwise occupied than with questions of decoration, a new departure in the use of iron came in vogue. Cast iron, by reason of its cheapness, and the facility with which duplicate pieces, of apparently fine design, could be produced, became very common. Designers ran riot in their ideas, and many monstrosities, embodying a grand jumble of styles, survive as reminders of the period. To gain the required strength, the cross sections were made heavy, the natural result being the production of cumbersome, awkward effects, as compared with wrought iron.

Still later, iron castings replaced wood and stone for many purposes, such as girders, columns and lintels. In our library are many text books, treating exhaustively of the design of girders of uniform strength and on the theory of columns, written by men who were the pioneers of the science of structural iron designing.

The so-called "Iron Buildings" naturally followed, and many are to be seen in our cities to-day.

The force of habit made the designers follow accepted architectural styles, and we find these structures made in the semblance of stone for columns, arches, pediments, etc., even to the imitation of the mason's chisel marks. The light shell castings covered real girders and columns, at first also of cast-iron, and later of rolled beams and shapes.

Such buildings represent an evolutionary stage, and as such; can be tolerated, yet the true principle of design and decoration is to make things strong and pleasing, by means of their own intrinsic qualities, suited to their duty and environment, and not by any sham veneer or other subterfuge seeking to disguise the truth.

Up to our own day, the evolution has progressed steadily, bringing as its latest development the modern steel-framed building, made possible by the wonderful achievements in iron and steel metallurgy, and the corresponding progression in our knowledge of the theory and practice of engineering, in its broadest sense. The phenomenal growth of our cities, and increase in land values necessitated a different order of structures, and American skill and ingenuity devised the means to meet the new conditions.

To-day, a modern office building is a triumph of engineering skill from top to bottom. The foundations, involving pneumatic caisson work and intricate and exact calculations; the skeleton, designed and figured as carefully as a bridge: the fireproof floors and walls, the iron stairways, rapid elevators, electric lighting, sanitary plumbing and ventilating—even the mail chute, all give evidence of the evolution of the engineer. But have the architects done as well for the exteriors as have the engineers for the interiors of these buildings? This is a large question, involving many new and difficult points, which are gradually being solved. It was a new problem to design a fifteen or twenty-storied building and still hold to conventional ideas of architecture. That some of our architects did not grasp the subject, is evident from an inspection of our streets.

But the change is coming, and we see in our own city to-day, buildings on which the architect and the engineer have worked in harmony to produce a design fitting the new conditions, with signal success. There are, however, numerous buildings in this and other cities, which are undoubtedly

strong and substantial and suited for their purpose, yet which appear absurd to a thoughtful observer. As an illustration : There is a modern building in Pittsburg, towering towards the clouds, having on the ground floor two store fronts, each about 40 ft. wide, with a stone lintel with vertical joints, running from pier to pier. The only apparent supports in the 40-ft. spans are some light cast-iron columns or posts, forming the window and door divisions. Resting on each lintel are two brick columns about 4 ft. wide, extending upwards many stories. If we were to really conceive of them as being sustained by the stone lintel we would have to completely revolutionize all our theories of the supporting power of iron columns and stone lintels. We engineers know that the plate girders behind the lintels, resting on iron columns behind the stone piers, really support all this weight, yet it does not appear so. Is it good design to make this stone lintel appear to carry the load on it, when the most casual observer would know that it would fail with one-tenth of the load, if actually carried upon it.

There are other buildings in Pittsburgh, such as the Carnegie Building, Tradesmen's National Bank Building, Hotel Schenley, and many others, in which the architects have successfully dealt with the problem, and while really supporting the structures by steel columns and framing, yet have given the impression of solidity, strength and beauty. Just how far we should follow precedent, in covering the bare columns with a facing of stone or brick, and in making imitation arches, to give architectural effect, is a problem for the architects, and not the engineers, to solve. It is the result of the use of iron in construction for which we stand sponsors. We will let the architects work it out, aiding them all we can. But there is a class of structures, for whose design we are directly responsible—bridges, viaducts, large roofs, iron buildings, and hosts of other work, that have not been handled anything like as well as have been the office buildings by the architects.

They are, as a rule, quaint, unsightly skeletons, only justifiable by reason of their utility.

That this condition is true, is perhaps not wholly the engineer's fault, for he works for others, and in this age of fierce competition, the tendency has been to eliminate everything extraneous to the actual need, from the design. Architectural effect requires consideration from the start, and if a structure is designed without regard to it, subsequent attempts at decoration, by means of towers, finials, or florid embellishments, but tend to make the appearance more inharmonious.

Artists tell their students continually, that to succeed in art, the first requisite is accurate drawing, and that no amount of pains-taking shading and coloring will redeem a picture inaccurately drawn. This is true, and we might well apply it in our own practice.

America, although again just through with another victorious war (all our wars have been victorious), is not now, as has been stated of an earlier period in its history, in an impoverished condition. On the contrary, we have reached the point, long since reached by some of our older neighbors across the ocean, where we are willing and able to pay the additional cost of making our surroundings more beautiful. Proof of this is not lacking in our own cities, for we have spent millions, and propose to spend more (derived from bond issues), on our parks, streets and bridges, on our court house and our armory, to make them an ornament to the city and a delight to all.

In this modern age, when knowledge is so much broader than formerly, it is impossible for any one man to be posted in all branches. In the engineering profession we are drawing the lines closer and closer, so that we have specialists for each line of work: railroad engineers, electrical, mining, mechanical, hydraulic engineers—each fitted and trained to his own business, and therefore experts in the respective fields.

When the electrical engineer needs an engine of certain

specifications, he does not attempt to design it himself, but consults the competent mechanical engineer or manufacturer to supply him. The mechanical engineer returns by asking the electrical engineer to furnish his works with an electric lighting or power plant. This is as it should be, but when it comes to designing a bridge or other structure, where the question of appearance is concerned, what do we do? We say to ourselves, "We can design such a structure; we know what a bridge should be better than any one else; an architect would be of no possible use." So we build something that certainly answers the purpose, but only in rare cases does it have any merit from an æsthetic point of view.

This is to be expected, for we have given our study and energy to the engineering problems, to the entire exclusion of æsthetic ideas, and we can no more suddenly, as if by inspiration, design a structure of appropriate and artistic beauty than we could paint a fine portrait or carve a group of statuary.

A notable example of failure, from the artistic standpoint, is the Fairmount bridge across the Schuylkill river in Philadelphia, leading to Fairmount Park.

It is a deck bridge, the vertical struts being enclosed by a fancy column and base, with arches of cast-iron sprung from one to the other, supporting a roadway, with massive cast-iron railing and corbels, all made in imitation of cut-stone work. The bottoms of the struts are connected with the customary eye bars and the diagonal members cross between them, so that from a distance, the lower chord almost disappears from sight, and we have the absurd effect of a great mass of masonry—looking like an old Roman aqueduct, suspended high up in the air as if by magic. Nothing could be worse from an artistic point of view. While this is an extreme case, there are very many structures to be seen in every city that can be justly criticized.

The obvious lesson is that for work that, by reason of its

environment and purpose, should be a decorative feature, the engineer should work in perfect harmony with the competent architect, each modifying his ideas to best promote the design as a whole.

The general scheme of the work should be mapped out, keeping the æsthetic side principally in mind, and making the engineering part contributory to the main end in view. That such a course is possible, is plainly in evidence in many European cities. Many of you have seen or read of the beautiful railroad stations of Frankfort, Cologne and Paris, in which the buildings, train-sheds, elevated approaches, columns, railings all harmonize with the general design, and yet in themselves are worthy of admiration separately.

In Paris, across the River Seine, are bridges of considerable span that, instead of being blots on the landscape, but add a greater charm to the river views of palace, church and castle that have made Paris famous the world over.

In some of the photographs of these works you can judge how successful the treatment of such structures has been when trained minds and hands have united in the designing. That both our architects and engineers can do as well is already in evidence, but there is room for very marked improvement.

In mechanical engineering, our earlier machines show ill-advised attempts at decoration. In *Cassier's Magazine* for December, 1898, is an article on machine design, well illustrated with pictures of lathes and planers, with architectural columns, panels, scrolls and flutings, entirely out of place on such tools. There are also given illustrations of modern machine tools, in which all attempts at decoration have been abandoned, and the outline designed solely for strength and convenience. That decoration and ornament, in the right place, is good, goes without saying, and it is equally true that decoration in the wrong place is bad. Let us, then, use our efforts to further the advancement of true art and beauty in engineering structures, and let us acknowledge our lack of

technical, true knowledge of the æsthetic part of designing, and leave that to those who are competent to deal with it, aiding them by our ability to carry out, as near as may be, their ideas.

This plea for better design of engineering work, is, perhaps, not strictly relevant to the subject of ornamental iron, yet it is really much more important to the engineering profession, than the history or art of working iron.*

Resuming the subject proper, a study of the methods employed by the mediaeval smiths, and the wonderful effects they obtained, as contrasted with modern methods of producing ornamental iron by machinery, from rolled or forged shapes, will be of some technical interest, and probably new to many of you.

Recalling the product of the early bloomeries and catalan forges as being rough bars or chunks, the mediaeval smith was compelled to forge out by hand, on the anvil, the special shape he required. As a result, articles for use were paramount, and decoration an after-thought. The first forms of window guards were plain squared bars, let into the stone, or having the ends flattened and nailed to the wood frames. Such forms are still used to-day. Perhaps the next step was to drift a nodule in a bar, when hot, as they had no power punches or drill presses to aid them, and inserting in the hole a round or square cross bar, pointed on the ends, and caulking it tight.

By making a bar a little wider and splitting it similar to a feather, and then curling up the slivers, excellent scroll effects were produced without any welding. Many examples of this class of work, adapted to various purposes, are found. The sketch shows clearly the process and results. This scheme was further carried out by forging out a sheet of metal, generally tapering towards the ends, and cutting it by hand chisels into various leaf or other forms, flat, and then bending

*Van Brunt & Waddell in "de Pontilus," pp. 39-54, and Moliter in Johnson's "Framed Structures," Chapter XXVI, discuss this point, as also Bolter, in his "Highway Bridges."

or beating them to some preconceived design. The older German hinges show this very clearly. As the knowledge of the art advanced, true scroll-work grills were made, the scrolls being welded to each other, or to the main stems, or secured by small encircling bands of iron, sometimes merely wrapped around, and the ends butted; in other cases, welded on. The welding required very quick work in handling heavy, awkward pieces, and yet holding the heat. Fig. 6 shows some of these earlier methods of working iron.

The number of combinations possible of simple C and S scrolls, is without limit. Heavy, strong guards and gates for prisons and fortresses were made by interlacing the bars or by running one bar through a hole pierced by a drift in a cross bar. The vertical bars or pickets often had sharp points, fantastically arranged.

The most difficult guards to make consisted of bars alternately passed through each other. It may be seen from the sketch what tedious, careful work was required, with increased labor as the grills grew in size. In fact, it is hard to understand how some pieces ever were made.

The decoration of scroll work with acanthus and other conventional leaf forms, followed. The flat shape was cut from plate, beaten by repousse work to the form required, and welded or otherwise secured to the grill. Such work calls for a high order of artistic feeling in the smith. Some followed designs made for them; others apparently made up the designs as they worked. Rosettes, flowers, faces, dragons—in fact, all kinds of designs were wrought in iron, with such skill as to challenge attention with the best of work in more ductile or easier worked materials. Beautiful samples of such work are to be seen all through Europe—and many photographs of choice pieces are shown you.

In the smaller pieces of work, such as hinges, locks, keys, knockers, etc., somewhat different methods are noticed. Plates, decorated with elaborately cut stencil work designs,

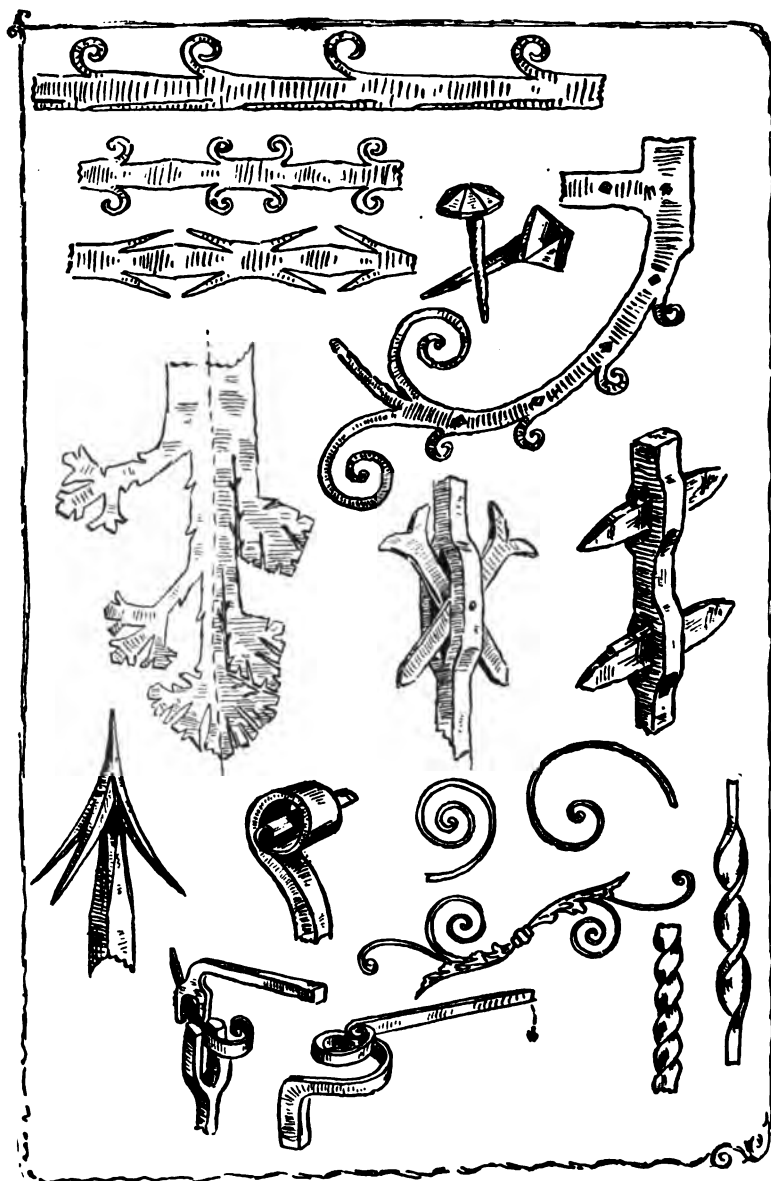


FIG. 6.—EARLY METHODS OF WORKING IRON.

often Gothic in style, were used in combination with repousse and chiseled work. Such work can hardly be classed as blacksmith work, as you may judge from the examples shown in Fig. 7. It is the work of artists, and some of it may be classed with the masterpieces of Benvenuto Cellini, the jeweler-sculptor.

Comparatively little work was riveted together and screws were unknown. Other methods were followed, which were the forerunners of our modern drop forging processes. When numerous pieces of similar relief design were needed, a matrix was made from a carefully wrought original by impressing white-hot metal upon it, until a sharp intaglio was formed. Subsequently reversals of this, made many exact duplicates of the original. It is probable that much of the relief work on the famous hinges of Notre Dame Cathedral, in Paris, were made in this way. The pictures of the details of their ornamentation, shown in Fig. 8, should be examined carefully, as they are famous the world over.

It would be wearisome to attempt to describe in detail even a very few of the magnificent pieces of iron work, or to enter more fully into the old methods of work, but enough has been said to give you an idea of what our ancestors did, with very inferior facilities at their disposal, and to show that, with all our modern machinery and improvements, there are some things that were done as well or better then than can be done now. The best work to-day is still almost entirely done by hand, and it is my pleasure to be able to show you some beautiful specimens of modern work in wrought iron, made by the Winslow Bros. Co., of Chicago, that compares favorably with the best of any age. I have also some photographs, loaned by Mr. O. Page, their local representative, showing fine work of different styles that they have executed.

In many other places, good work is done by such concerns as J. B. & J. M. Cornell, and John Williams, of New York; Krug & Son, of Baltimore, and others. Up to very



FIG. 7.—DOOR KNOCKER AND ROSETTES, GOTHIC, 1460.

recently, there has but little really fine work found sale in Pittsburg. The majority of workmen on such work are foreigners, who have been trained in Germany or France, where most beautiful work is made, as all will acknowledge who saw the fine exhibits at the Columbian Fair in Chicago.

In America, the fire-proof building has made a demand for iron stairs, elevator enclosures, and other work in iron, that has been met by a combination of wrought and cast iron, with bronze and other metals. Cast newels, stringers, fascias, with wrought iron grilles and railings, are now used, that have never been equaled, either in design or workmanship. The designs for the castings are first modeled in wax by artists, plaster molds and cast obtained, and an iron pattern made and tooled, until the very character of the original is obtained. Then careful molders, with fine sand, reproduce the pattern. The casting is cleaned and parts polished, and in the best work electroplated with some desired finish, to preserve it from rust and to please the eye.

The railing and newels before you show how clean-cut and smooth such castings can be made. Such work calls for thorough knowledge of ornament and design, engineering ability to determine the strains and stresses, and mechanical knowledge of a high order to accomplish the results, together with large capital invested in machinery, patterns and buildings.

There is a class of work, lying between the fine work described and structural iron work and bridge building, embracing fences, railings, stairs, sheds, ornamental roofs, and other work, where ornamental effects are desired, but also where cost enters to prevent the employment of the highest class of work. Great numbers of duplicate pieces must be produced at low cost, both for material and labor. Methods of assembling the pieces must be devised that will be rigid, yet allow of rapid work. The modern manufacturer has at his disposal a host of advantages and resources, unknown to his predecessors.

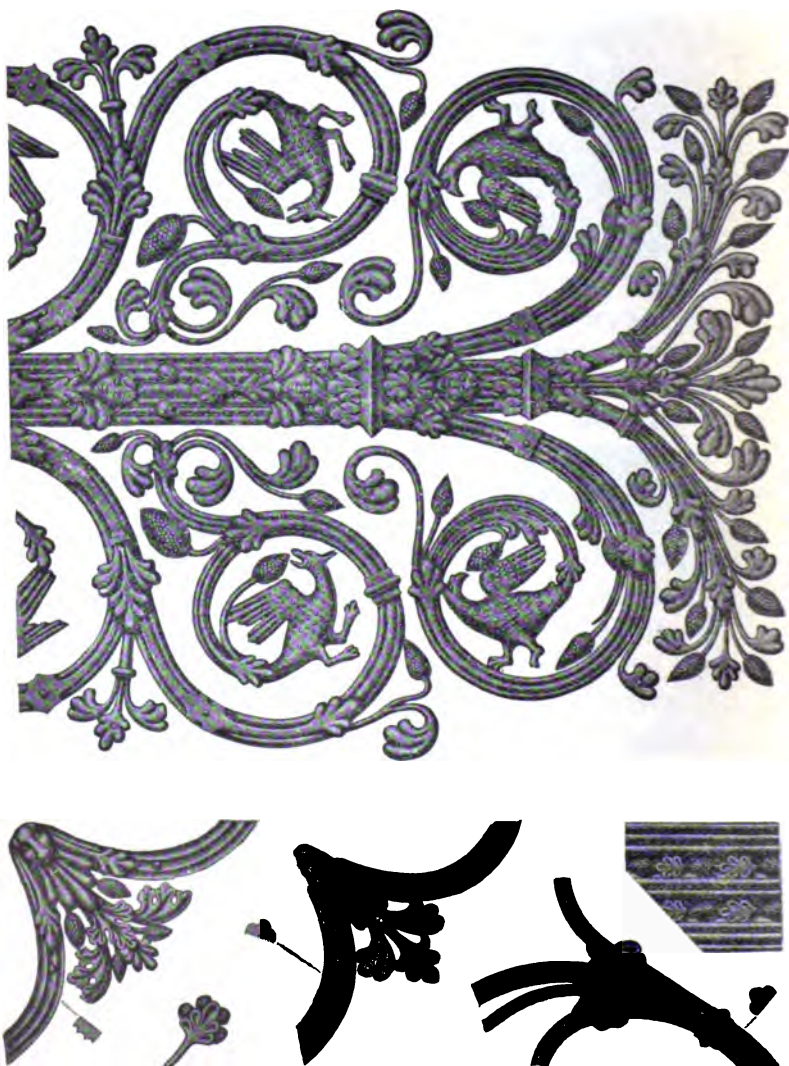


FIG. 8.—DETAILS OF NOTRE DAME HINGES, TWELFTH CENTURY.

Primarily is to be placed the product of the rolling mill, giving the manufacturer choice of material rolled in almost any desired shape and size and of any specified quality. The invention of labor-saving machinery of all sorts has made entirely mechanical much that was formerly only to be accomplished by the skilled mechanic by hand. Thus punching, drilling, riveting and tapping, with shearing and bending, can all be done, to a very great extent, by machine. As a result, the easiest way to get certain ornamental effects is no longer as practiced by our forefathers, but on modern lines. We often see work to-day, put together in imitation of the earlier methods, for the sake of effect. This may do for occasional pieces, but for any larger quantity of work it would be wasteful and rather foolish.

In addition to rolled shapes of the ordinary bar, plate or structural mill, we can now obtain certain special shapes, made exclusively for ornamental work. Mouldings, both plain and decorated, in great variety of size and contour, suited for many different kinds of work can be purchased. They are made in Germany and the samples shown you and illustrations of the obtainable sections demonstrate that our rolling mills can learn a good deal from our brethren across the water. The mere fact that there is a market in Germany for such material is of itself an argument as to the character of their iron work, from an æsthetic point of view, for I know of no mill in the United States that can approach this work in character or finish.

Drop forged pickets, rosettes of all shapes, leaf forms, and various other decorative designs, well illustrated in Braun's catalogue, can be had, as also a large choice of hand-made leaf, flower and other work that could not well be machine made. I show some samples from Chas. G. Eckstein, Manufacturing Agent, New York City.

By the use of the ordinary and extraordinary kinds of material described, the iron worker of to-day has only to sketch

out his idea full size, modify it a little here or there to fit the catalogue lists, order his material and work it up to produce work that in appearance, strength and workmanship combined with uniformity and cheapness of production, is the par of any produced by entirely hand work. But even this class of work is too costly for use where very large quantities of duplicate work is required, and hence means are used to produce ornamental effects, at the very lowest possible price; in fact, at prices that vary but slightly from the present pound prices for bridge work.

As an illustration sometimes conveys information much better than whole volumes of books, a full detail of a panel for the Harlem River speedway railing for New York city, designed by Prof. Burr, of Columbia College, is shown in Fig. 9, in which the rosette is omitted in our picture to show the

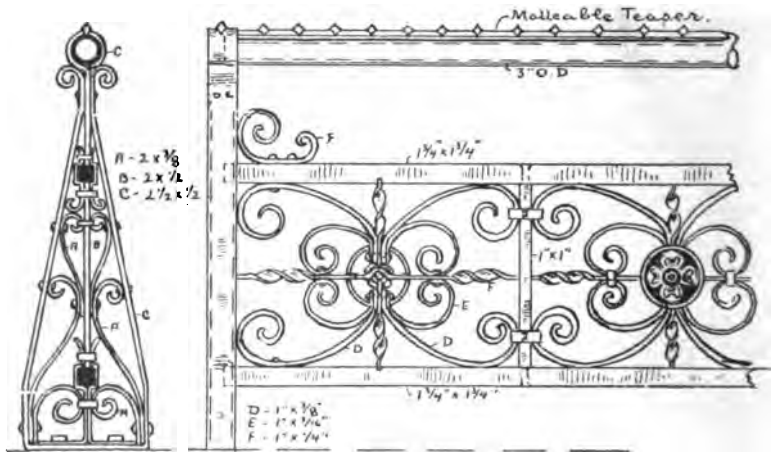


FIG. 9.—RAILING FOR HARLEM RIVER SPEEDWAY.

construction. The top rail was casing and all the holes were punched by using a long bar, carrying die in end, inside of tube and a holder outside. The "teaser," or cast malleable iron pointed top piece, was all *punched and sheared to gauge*.

The small round projections, fitting in top pieces of post, were to prevent the pipe turning. The $1\frac{1}{4}$ " sq. rails were really steel billets. The holes were at first punched, but as that swelled out the bars, they were later drilled, except the depressions, holding the vertical twists in place, which were punched. The twists were machine made, cold. I have some samples of heavier work, also twisted cold by machines. The nicks, or offsets, were pressed under a punching press. The scrolls were first sheared and punched, then bent over former to the required shape, all to gauge. The scrolls were assembled as shown, later being fitted into the special cast rosette, and finally the bands put on and clinched with a dove-tail as you see.

The post was more difficult. Most of the smaller pieces were first punched, then passed through "bull-dozer" for preliminary bend, then through special hand or machine formers to give final shape. The exterior part was gauge-punched, scrolls beaten out and turned, and finally dropped into a form and both sides drawn around as indicated. Thus, each part was made up by the thousands, brought to the assembling spot, riveted or clamped, and passed on for painting and inspection, most of the work being paid for by the piece. As there were many grade panels, requiring special dies and forms, very close watch had to be kept to keep the pieces separated, for the external appearances were very similar. There was some 17,000 feet of this railing, weighing 60 pounds per lineal foot, or considerably over one million pounds of this comparatively light work. To lay off the vast number of duplicate pieces to be sheared and punched would be very slow and expensive work. This is avoided by means of little jigs and gauges. One that is quite simple, for accurately spacing a lot of holes irregularly spaced along a number of bars, is to lay off the required holes, reversed, on a bar, screwed to a table, so that the bar is in line with the punch; a little dog, with a projection just fitting into the holes described, is made,

having a little upwardly-projecting lip. Inserting this dog into the hole furthest from the punch, the bar to be punched is shoved against the lip and hole punched in other end. The dog is moved to next hole, bar put again against lip, and hole punched in other end, of course just the required distance from the hole last punched. All that is necessary is to have the bars cut off the right length, and no other laying out is required.

Special punches and dies are continually required, a few being placed before you. Scroll formers, both for hand, former and machine work, are here, with some samples of work in different stages. In order to execute this class of work quickly and cheaply, hand work must be largely eliminated, and the ingenuity called upon to devise jigs or processes to avoid it. Architects and, alas! bridge and structural engineers, often entirely overlook these features, and wonder why some designs of their own cost so much more than others apparently calling for much greater labor in construction. It is, of course, due to a failure to understand the construction of such work from the manufacturing standpoint, and if the designer would call in the assistance of the practical man, it would often save a great deal of needless expense, and generally result in very much improving the design of the work.

DISCUSSION OF PAPER.

MR. FLANAGAN:—I was glad to notice that Mr. Albree dwelt to some extent with reference to the architect working in harmony with the engineer.

I would like to ask Mr. Albree how long those pieces of pipe were that were punched.

MR. ALBREE:—The pieces of pipe were $6\frac{1}{2}$ feet long and had holes 8 inches apart.

MR. H. P. MILLER:—What sort of a jig do you use in punching the holes?

MR. ALBREE:—Practically the same jig.

MR. FLANAGAN:—Mr. Bole suggests that the spur was put there to prevent the boys from slipping off the fence.

On motion the meeting adjourned at 10:45 P. M.

REGINALD A. FESSENDEN,
Secretary.

MEETING OF CHEMICAL SECTION.

PITTSBURG, MARCH 23, 1899.

The regular monthly meeting of the Chemical Section of the Engineers' Society of Western Pennsylvania was held at the Society's House March 23, 1899.

Chairman, E. S. Johnson.

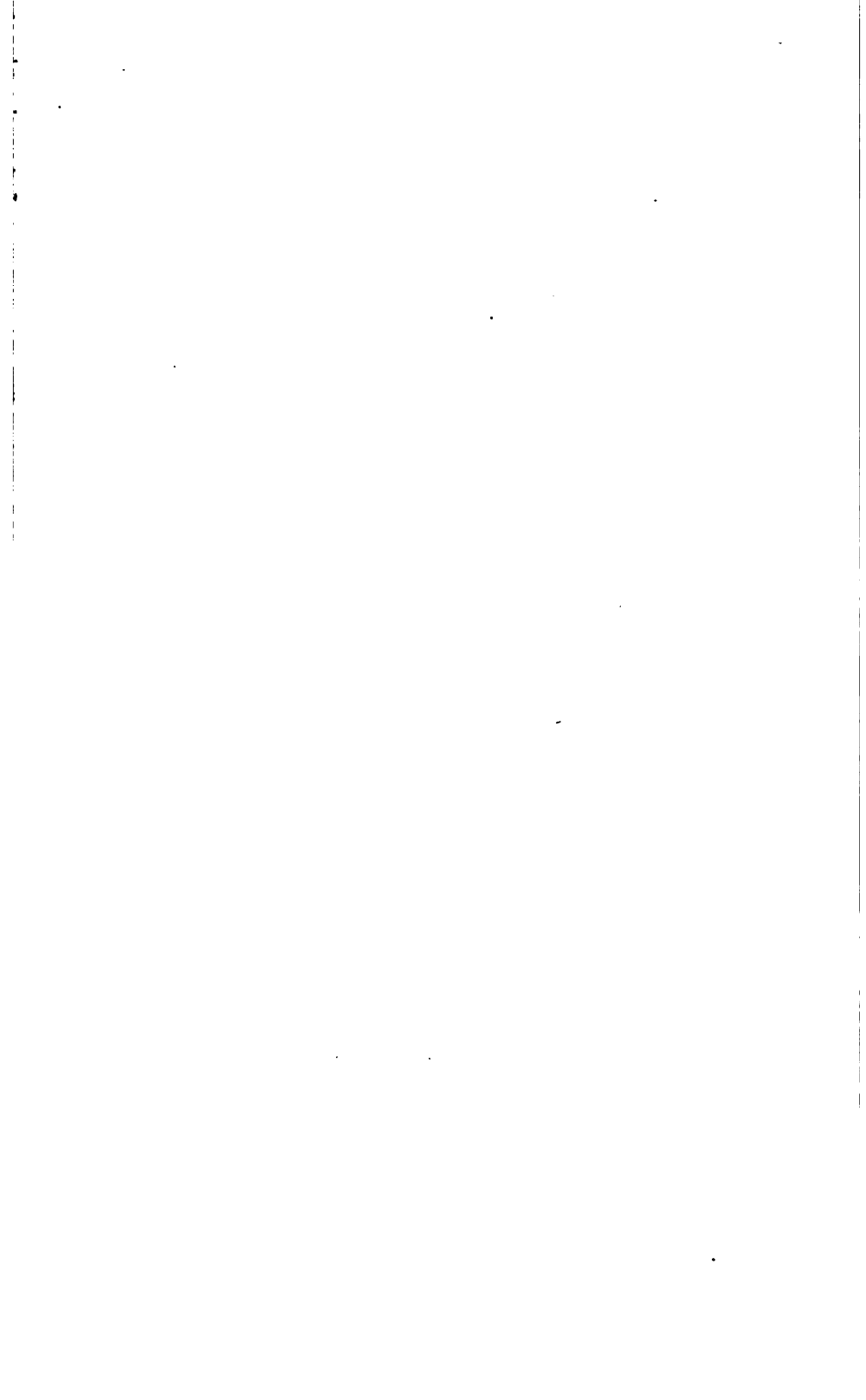
Attendance, 10.

The minutes of the last regular meeting were read and approved.

Dr. Phillips reported that a meeting of the Sanitation Commission had been held, at which Mr. Wm. Kennedy had been elected Chairman for the coming year.

Some very interesting abstracts from recent chemical literature were read by Dr. Phillips and followed by an informal discussion. The Section adjourned at 10 P. M.

A. G. McKENNA,
Sec. C. S.



ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA,

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The one hundred and ninety-fourth regular meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the Society's House, 410 Penn avenue, Pittsburg, Pa., Tuesday evening, April 18, 1899.

The meeting was called to order by the President, Mr. Harry J. Lewis, at 8:35 P. M., thirty-five members and visitors being present.

The minutes of the preceding meeting were read and approved.

For the Board of Directors the following applicants were reported as passed and to be voted for at the next regular meeting :

EDWARD F. AUSTIN,	-	Representing Stillwell, Bierce & Co. and Smith Vaile Co., Dayton, Ohio, Room 203 Smith Building, Pittsburg, Pa.
CLIFFORD G. DUNNELLS,		Assistant Engineer, with the Pittsburg Bridge Co., Pitts- burg, Pa.
ROBERT GEDDIS,	- :	Salesman for Jones & Laughlin, Ltd., Pittsburg, Pa.
H. J. GLAUBITZ,	- -	Mechanical Engineer, with Julian Kennedy, Pittsburg, Pa., Clayton ave., Allegheny, Pa.
WILLIAM H. GOULD,	-	Assistant Engineer for Pittsburg Bridge Co., Pittsburg, Pa.
ALFRED W. SPENCER,	-	Engineer, with Hyde Bros. & Co., 902-3 Lewis Building, Pittsburg, Pa.
ADAM P. TANNER,	- -	Mechanical Engineer, with Julian Kennedy, Pittsburg, Pa., 6356 Marchand st., Pittsburg, Pa.
LAWRENCE R. WHITE,	-	Manager, Pittsburg office of Frick Company, Waynesboro, Pa., 51 Schmidt Building, Pittsburg, Pa.

The following gentlemen were balloted for and duly elected to membership :

WILLIAM AHLEN, - - -	Chief Draughtsman, Duquesne Steel Works and Blast Furnaces, Duquesne, Pa.
CARL B. AUEL, - - -	Engineer, with Westinghouse Air Brake Co., Amber Club, E. E., Pittsburg, Pa.
CHARLES H. BRADLEY, JR.,	Manager, C. H. Bradley, Jr. & Co., Engineers, 58 Vandergrift Building, Pittsburg, Pa.
RUNHARDT DAAE, - - -	Draughtsman, with Julina Kennedy, No. 3 Highland Place, E. E., Pittsburg, Pa.
GEORGE W. KNOTTS, - -	Mechanical Engineer for National Rolling Mills Department, N. T. W. Co., McKeesport, Pa.
FRANK S. LOEB, - - -	Metallurgist and Assistant Sup't, Duquesne Reduction Co., Pittsburg, Pa.
ROBERT McLAUGHLIN, -	Draughtsman, with Westinghouse Machine Co., 318 St. Clair street, Pittsburg, Pa.
HENRY OTTO, - - -	Master Mechanic to Shoenberger Steel Co., Pittsburg, Pa.
WILLIAM O. RENKIN, -	Mechanical Draughtsman, with Pittsburg Plate Glass Co., No. 5 Fulton street, Allegheny, Pa.

For the Committee on "Abatement of the Smoke Nuisance," Prof. Fessenden reported progress.

Under New Business, Prof. Fessenden reported the recent death of Mr. Peter Doxrud.

On motion of Mr. Frans Engstrom, it was voted that the President appoint a committee to draft an appropriate memorial. The Chair thereupon appointed Messrs. Frans Engstrom, Edwin Ruud and O. C. Opsion.

The paper of the evening, entitled "Quick Revolution Engines," was then read by Mr. Arthur Herschmann.

QUICK REVOLUTION STEAM ENGINES. ✓

BY ARTHUR HERSCHMANN, A. M. I. M. E.

In these days of rapid changes, when novelty of conception and record-breaking proportions of mechanism attract more attention than anything else, one has almost to apologize for reading a paper on the steam engine—a field in which, so it would appear to the layman, no progress has been made since the days of James Watt. Indeed, Watt's condensing engine of 1768, with a coal consumption of 9 lbs. per h. p. per hour, remained unaltered in 1804 when Woolf added his second cylinder, in 1850 when John Edler compounded it, and when the triple expansion engine became introduced in 1870 the coal consumption was only lowered to 1.7 lbs., a figure which we know does not yet represent 15% of the theoretical value of the coal burned under the boiler. Since that date little progress has been made to improve economy; the attempt to introduce a system of four-fold expansion having proven, we may say, valueless. The practice of running engines with superheated steam, which had to be abandoned in the early 40's, when Hirn in Germany, and Clark in England, demonstrated the advantages to be gained by the use of superheated steam, became revived in recent years, favored by the improvements which have been made in packing material, heat resisting lubricating oil, etc., and characterizes a departure in engine building, which however is not as marked as the advent of the quick revolution engine, the type which shall concern us to-night.

It was not until marine practice taught stationary engineers about the possibilities of running well-designed and well-built engines at a high rate of speed, and not before the days of electricity that the high-speed engine became appreciated.

Afterwards, assisted by contemporaneous improvements in shop practice, the high-speed engine came to stay. The requirements of modern competition and the general tendency in all branches of manufacturing to speed up machinery, so as to increase its hourly output, and the desire to economize the space assigned to the power plant, opened up a wide field of application for the high-speed engine, which latter enables one to dispense with intermediate shafting and the frictional losses consistent with its use. To-day the high-speed engine is so popular that even in the manufacturing district of Northern England, where still many a new beam engine is being put down, to suit the fancy of Ben, the engineer, or Jim, the mill-wright, the vertical quick-running engine is growing in favor as a mill-driving motor. Naturally it has been tried to speed up vertical Corliss engines, but it has been found that the limit for a "trip-gear" is in the neighborhood of 120 revolutions.

Tracing back the introduction of the high-speed engine we find that for a long time it could not gain recognition alongside the Corliss type of engine, which latter, being then a universal favorite, differed from the former considerably and in the most important details. We know that at the time, when Corliss introduced his engine, there was no other variable expansion gear known which the governor could control as easily and precisely as a Corliss "trip-gear," and that Corliss was ahead of his time with both the design and the workmanship of his engine. Twist valves, piston and drop valves fall in a later period, and the old Meyer gear, like many of its modifications, could not be efficiently negotiated by a sensitive governor, as an efficient gear must not act back on the governor. Economy and good regulation, therefore, secured a monopoly for the Corliss engine, and incidentally the notion spread that nothing but a slow-running engine could give good results. Of course, the piston speed, the real measure of speed, is still higher in a slow-running Corliss

engine than in most high-speed engines. The characteristic features of the superiority of the Corliss type of engine became, however, less prominent when instead of driving factories having a steady load, small dynamos of varying load had to be driven, (as direct as possible to avoid sluggish governing), and when the frictional loss of mill gearing, once the chief load of many industrial establishments, became reduced through the introduction of the now popular swivel bearing and other improvements in the transmission of motive power. The original Corliss engine, moreover, was not capable of a very wide range of "cut off."

To govern quickly and within wide limits we had to have, instead of a very heavy flywheel, more impulses on the crank shaft per unit of time. As the variation in the load will cause the governor to affect, at the very best, the next stroke and cut-off only of the engine, it became desirable to shorten this stroke and repeat it proportionately often during a given time.

It may be of interest to state that this evolution of the quick-revolving engine does not seem to have taken place in the different engineering nations at the same time or in the same manner. English engineers, with their large experience in marine practice and with their preference for vertically arranged cylinders, which latter have for a hundred years proven to be a desirable feature with beam engines, developed early the type of engine known as "inverted vertical" or marine type. (See Figs. 1 and 2.)

In this Country the experience in the accurate building of machinery enabled you to demonstrate the fallacy of the belief that great speed per second means great wear and tear, and an engine was developed, characterized by light moving parts, well balanced, shaft governor and utmost simplicity of design.

In Europe the high-speed engine was longest opposed and considered an absurdity. The reasons for this are not far to seek. In the first place, electrical machinery was run at

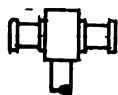
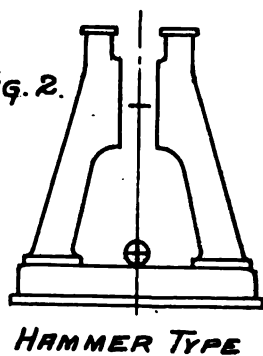
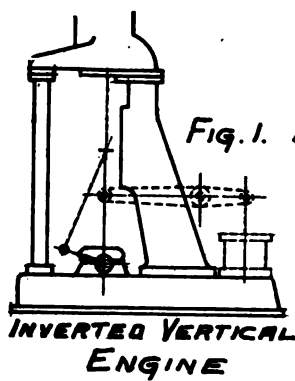


Fig. 3,

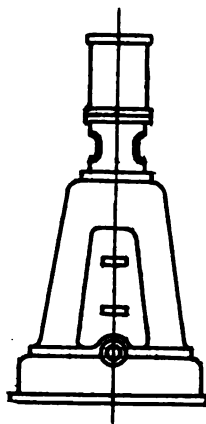


Fig. 2n.

lower speeds and the tendency there was and is to build large and slow-running dynamos and match the speed of the engine, whilst in this country and in England the engine became speeded up to match the dynamo speed. Secondly, scientific considerations and theory, however useful in general as a guide and telling us what we should not attempt to do, are deluding in this case and against the high-speed engine. Theory and precedence being more regarded there than in this country, the features of short stroke, small expansion and large clearance sentenced this engine. As a passing remark we may state here that clearance which averages 15%, reaching as much as 25%, will seldom be found excessive, being essential to cushion the engine. It is now more generally understood that in every engine the economical limit of expansion is sooner reached than its possible theoretical degree, owing to increase of heat—and friction—losses in larger cylinders, and that here Lord Kelvin's law of economy, defining the relation of increment of capital to advantages to be derived from such additional expense, should, as in so many engineering problems, receive first attention. It should be also considered that it makes no difference to the user of an engine whether he pays with his money for coal or for capital charges, and that with this commercial end in view, speed, gear, or type of engine, are subordinate considerations.

At the recent exhibition of Brussels, Belgium, I saw so-called "improved" Corliss engines, representative of the taste of the French and Belgian designer. It seemed to me that they were too perfect to be entrusted to the care of imperfect human attendants and that they had too many rods, joints and packing boxes. A quick-revolving engine, on the other hand, would be simple, reliable and have all the moving parts accessible and quickly renewable. After this somewhat historic review, I should like to consider the present practice and then discuss the merits of a few representative types of quick-running engines. The subject is very large and we can

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to-night only describe a few engines ; I shall not consider rotary engines or turbines, and shall restrict myself to engines in England and on the continent of Europe, thinking that such information will be of most interest to you.

In this country of cheap fuel, generally speaking, you find the non-condensing type of engine to prevail and in particular where the water is dear; in Europe condensers are insisted upon, wherever it is possible to install them. Preferably the driving of these condensers, or rather air pumps, is effected direct from the crosshead of the engine (see Fig. 1) and this tendency has developed the so-called High Speed Engine there, running at 150 revolutions or thereabouts. The air pump in such engines is single acting and often a cigar shaped plunger (see Fig. 3). I think Franco Tosi, a large engine builder in Italy, was among the first to build an engine on the lines of the Armington-Simms engine, but with an independent belt driven condenser, situated beneath the engine. The modern tendency is to use direct acting air pumps and to connect all the exhaust pipes of a plant to a central condensing station.

A point which cannot escape the attention of the observer is that single acting engines are not in favor in Europe, though they should appeal to the theoretical designer. High speed engines with rotary valves, arranged similar to those of the English Brotherhood engine, are being manufactured in some quarters, but they have few advocates. I saw one engine of this type at Liege, Belgium, having rotating valves arranged vertically and therefore less liable to wear; this engine was very simple and showed good results.

Concerning the action of the steam, we find that although the single acting engine preceded the double acting, the former has only in recent years become a prominent type.

A single acting engine is not liable to knock if properly cushioned; there is only a downward thrust and the direction of the strain in the moving parts is not changing from tension

to compression as in double acting engines. It is frequently pointed out that this very quality will prevent a good lubrication of the brasses, but experience has sufficiently demonstrated the fallacy of this contention in all cases where the bearings are not skimmed down in their surface. As a rule the designer will find that on account of the large cylinders required for the single action, the centers of the two adjoining sets of engines will have to be far enough apart to allow of ample provision being made for the bearings. The "Willans" engine (see Fig. 4), built at Rugby, England, is the most popular engine of this type in England, she is enclosed and splash-lubricating like the Westinghouse engine and has many good features in its design. The engine has a central valve located inside the hollow piston rod, the cut-off is effected by the piston rod and therefore very rapidly at piston speed. There is only one joint in the driving gear of the piston valve, and the engine is very compact and can to a great extent be built on a lathe.

Compound high Speed Engines are the rule, at least for electrical purposes, and they are built with two or three cranks, or what is the same thing, two or three sets of cylinders. If run non-condensing, it is customary to fix on a suitable cut-off and govern with a throttle governor in preference to regulating with an automatic expansion gear, which latter is apt to cause a drag in the large low pressure cylinder at light loads, cutting off early. Where it is the intention to run the engine periodically condensing, say when there is ample water to be had or during summer time only, when the exhaust has not to heat the shop, it is advisable to hang the eccentrics on fixed discs and to make them adjustable so that they can be readily thrown over to vary the required "cut-off" (see Fig. 5). A pointer arrangement serves in such cases to indicate the position of the eccentrics. An engine of this description which has proven very useful is shown on one of the photos.

The double acting engine has the advantage of being, generally speaking, of smaller proportions, and of being rever-

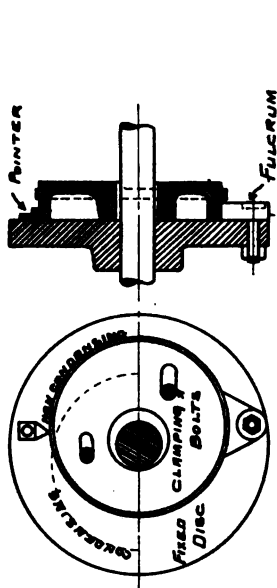


Fig. 5.

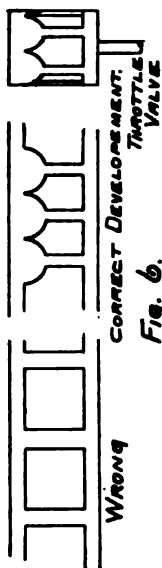


Fig. 6.

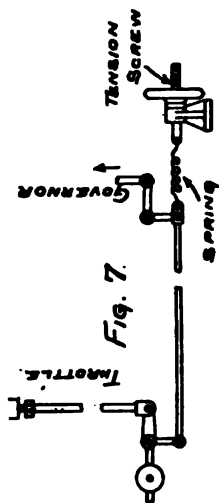


Fig. 7.

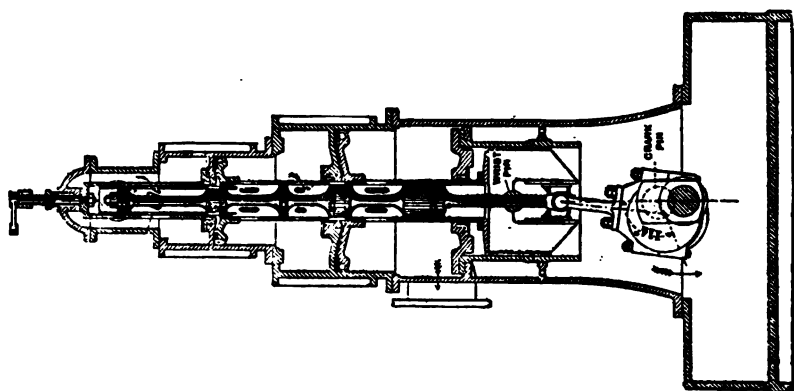


Fig. 4. Williams High Speed Engine.

sible should this feature be desired. It is here only just to state that even at very high speeds the change of stress in the moving parts will not cause knock, or show undue wear, if the steps in the rods and brasses in the bearings be properly fitted and adjusted, and that this very change of direction of stress will facilitate lubrication. With pressure lubrication, which we shall consider later, there will be always a quantity of oil ready to force its way into the brasses, as soon as the reversal of stress takes place.

As regards the number of revolutions, 500 to 600 is the maximum with small English engines, whilst Continental Types will seldom reach 300 revolutions; of course these figures would have to be greatly reduced for heavy engines, and I think for instance that it would for different reasons not be advisable to run a 1000 H. P. Engine at a higher speed than say 100 to 200 revolutions per minute.

It has to be borne in mind that in speeding up an engine we increase its power in a linear measure while the centrifugal strain, caused by the inertia of the moving parts, grows with the square of the velocity. The latter strain affects the moving parts for which we cannot allow too much space without sacrificing the first object to be aimed at in the construction, which is compactness. Naturally the price will also go up with a very high speed, as the design will have to be one embodying the best details of construction and the material employed, as well as the workmanship, will have to be of the highest order to ensure good results.

The regulation of the engine and in connection therewith the selection of a suitable valve gear is a subject on which opinions differ very greatly.

In the case of an electric light engine for instance, it used to be customary to specify that the governor should keep the engine within a speed variation of as low as $\frac{1}{2}$ % between full load and running empty; later it became understood that this close governing was not as important as it first seemed to

be, in fact dynamos began to take care of themselves and their output, electrically (winding of dynamos) and more importance was attached to the even running of the engine which was insured by increasing the number of impulses on the crank-shaft through the arrangement of two and three sets of cylinders and as many cranks arranged at right angles or at 120 degrees. It is a common experience with electric light that the constant and small fluctuations are more annoying to the eye than the slow waves, changing between light and dark.

With reference to the governing, it will be observed that while the automatic feature is prevalent in this country, in England the throttle governor is growing in favor. The throttle is hardly as sensitive as the automatic valve, however close we put it to the cylinder, and its action is not as rapid as that of an automatic valve, but as before discussed, it is sufficiently so with a multicrank engine, which type of engine prevails on the other side of the ocean. In any case the throttle valve proper should have a correct development (see Fig. 6), a point which is not always watched. As regards economy, throttle governing gives excellent results for steady loads, whilst in cases where a great variation of load has to be met, we are compelled to set the gear and fix the eccentric for the latest "cut-off" and the maximal load, or rather for the load which is likely to occur most of the time, so that the engine will run less satisfactorily at light loads. Where we have a low steam pressure, this disadvantage of throttling decreases, though in any case throttling means that the exhaust will carry away more of the heat because the maximum pressure has extended over a comparatively large part of the stroke. The latter loss increases perceptually as the work of the engine decreases.

The automatic engine on the other hand has the disadvantage that the maximal pressure always occurs at one end only, so that there is a great difference in the energy card of such an engine, necessitating the use of larger parts; increase of

expense will result, as well as increase of friction, since we have to use a large flywheel to enable us to work with great expansion and a drag at light loads may also occur if cylinders are too large. An advantage that the automatic engine has is that it will not allow the engine to run away when the load is suddenly thrown off, since the governor when reducing the "cut-off" will automatically increase the compression and thereby pull up the engine, whilst with throttle governing when the throttle valve is leaky there is in certain types of engine a chance that sufficient steam reaches the cylinders to keep the engine racing. It should be said that the automatic feature is a safeguard in this respect only where a single valve is employed, controlling the compression as well as the admission, as there are most engines, particularly those having two cylinders, in which two separate valves are arranged and in which the distributing valve is not affected by the governor. Whether in the case of the throttle or the automatic engine, the shaft governor is being universally employed; it dispenses with troublesome intermediate gearing to run the governor, and makes the engine more safe, sensitive and compact. In many designs the "governing centre," as it were, of the engine can be altered at will by means of an attachment at the side of the flywheel governor. (Such a device is shown on the photo of the little horizontal engine). It consists of a handwheel and screw externally arranged and acting on the tension of the governor springs, or affecting the leverage of the centrifugal weights. In the case of throttle governing such a speeding device is very simply produced by interposing a spring and tension screw between governor and throttle. (See Fig. 7.)

As bearing on the economy of quick running engines we shall consider the ratio of diameter and stroke and how it affects the amount of "cut-off" to be employed. For a given horse power and piston speed, we assume for the sake of comparison that in one case we have a long stroke engine,

one square foot piston area and five foot stroke, and compare this with a quick running engine, of five square foot piston area and one foot stroke. At 20% cut off we find the surfaces exposed to the condensing action of the steam to be four and one-half square feet for the long stroke and 13 for the short stroke, but at 60% we find this surface to be eleven and one-half in the first instance and only 10 square feet in the case of the quick running engine. (See Fig. 8.)

We find, generally speaking, that both types have same piston speed, but that the short stroke engine makes four times the number of revolutions of the long stroke engine, therefore there is less time for the condensation of steam to take place. Of course this calculation would not be correct if we considered the large port surfaces of small engines. In any case we see that quick running engines should have a large cut-off and that there is not much use for "jacketing," an arrangement which is very generally used in Europe. It is, on the other hand, only logical that we should cut off as early as the load will permit, but this would, in long cylinders, as we have just seen, give great loss from condensation.

Much could be said about good features in the general design of high speed engines, but I shall only briefly touch a few.

Whilst horizontal engines are the rule in this country, the vertical inverted type now prevails on the other side; the frame of this engine consisting generally of a cast iron standard, accommodating the crosshead guide, the front being as a rule made more accessible by letting the cylinder rest on one or two wrought iron or steel columns, respectively, three in the case of a two-crank engine, or four in the case of three cranks. The early types are of the hammer pattern (see Fig. 2), having standards in front and back which enables them to be more reversible, should it be necessary.

The tendency is to enclose the running parts within a sur-

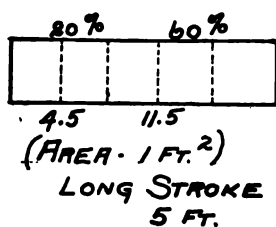


Fig. 8.

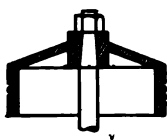
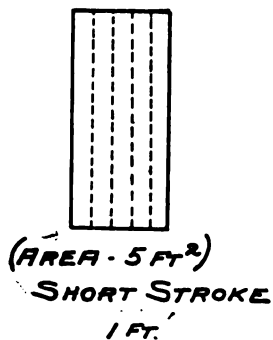


Fig. 9.

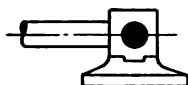


Fig. 10.

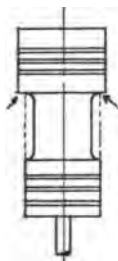


Fig. 11.

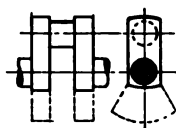


Fig. 12.

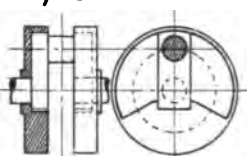


Fig. 13.

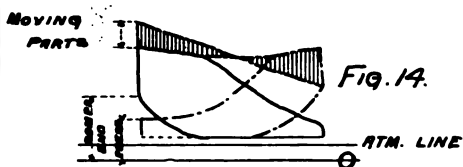


Fig. 14.

rounding and oil-tight frame (see Fig. 2a), access through which latter can be gained by removing suitable covers or opening regular doors, provided in same, which arrangement is indispensable in the case of forced lubrication, which popular lubrication we shall consider presently. Soft packings are still largely used, but the metallic packing is never disregarded where good work is concerned. A cheap substitute for a packing can occasionally be met in high speed engines, (mostly to separate the low pressure cylinder from the high pressure in tandem engines,) which consists of a plain bushing with a few narrow grooves turned on the inside to act as steam cataracts.

Grid valves, favored in this country, are practically unknown on the other side, where piston valves are almost generally used. Their use involves the equipment of the cylinder with spring relief valves. The piston valve gives a port opening all around the circumference and therefore large. Many engineers would not have a piston valve without a bushing or liner and there is also a difference of opinion whether these valves should be packed or plain. My experience is that most attention should be paid to the manner in which the piston valve is being driven, the valve spindle should be as light as possible and the stuffing box, through which it passes, should be of a high class. Under such circumstances there should be no necessity for a packing of the valve and a few narrow grooves turned on its outside will make it sufficiently steam tight. My opinion is also that a separate liner is not required if the valve is light, properly finished and its seat in the cylinder casting well lapped.

A case came within my observation, where complaint was made that the valve had badly scored its seat and that this would not have occurred had a special liner been provided for its seat. The fact of the matter was that the valve seat had been finished by means of emery powder which was not carefully removed before setting up the engine. This, by the way, can be avoided in having the finished cylinder casting blown and

cleaned with compressed air, a process superior to the application of steam for this purpose.

The greatest amount of attention has to be paid to proper design of moving parts, pins, slippers, bearings and eccentrics. These have now not only to be sufficiently strong, but also large enough to prevent heating, and to avoid that the oil is squeezed out from them, due to great specific pressure. The inside of cylinders are generally polished to minimize surface and therefore reduce condensation. The joints of engines of a high class are scraped and oil is only used for making the joint. The next best practice would be to use thin wire gauze and red lead. In any case it is important that all the joints are so arranged that it is not necessary to disturb them to effect minor repairs on the engine. The pistons of upward from say 14 in. should be light and solid, with *broad faces* and *narrow* well fitted (Ramsbottom) *rings*, usually 3 in number (see Fig. 9). Pistons with junk rings or those having screws for adjustment should be avoided wherever possible in quick revolving engines.

The piston rod is, with the best types of such engines, forged in one with the crosshead block and the latter is fitted with registers to dispense with heavy clamping belts to take shearing strain (see Fig. 10). The tendency is to design the parts so that the attendant of an engine should not have much chance to apply his own judgment in the matter of adjustments. Every high class engine is equipped with spring relief valves, which, on the vertical engine, can be to advantage combined with the drain and indicator cocks in one casting or fitting and coupled together and driven from below with one lever equipped with an indicator segment to show the working position of the fittings.

Opinions differ as regards the value of double nuts to prevent the jarring loose of the bolts. I should only use double nuts on crankshaft pedestals and otherwise supplant them with high single nuts, fine thread and split pins. Spring washers will be found to give good results.

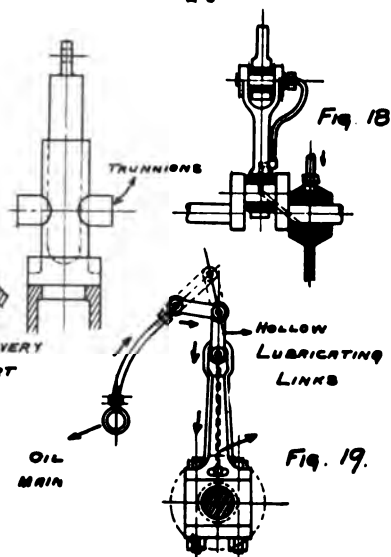
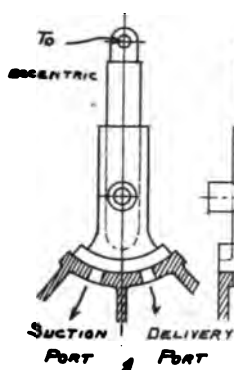
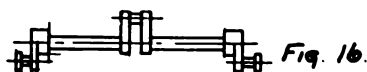
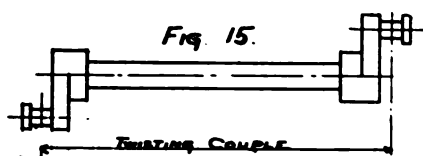
Too much attention cannot be paid to the matter of balancing. It is a good notion to balance large vertical piston valves by enlarging their upper steam-exposed ring surface so that the steam will counteract their weight. To balance the moving parts, it is customary to either enlarge the crank diametrically opposite the crank pin or else to clip a separate balancing casting around the webs.

An amount of compression should be provided for, so, that at dead centres, it will be equal to the end pressure of the steam on the piston, plus the inertia of the moving parts of the engine, otherwise a knock will occur. Some builders of quick running engines prefer to let the thrust change its direction before dead centres; but of course it is irrelevant where this reversal takes place as long as it takes place quietly. It can be noticed in some vertical engines that the shaft does not fall in the same vertical plane as the axis of the cylinder.

The arranging of two cranks, side by side, with centres opposite, is an efficient means of balancing the vertically moving parts of an engine; it also facilitates lubrication by relieving the main bearing periodically, but this is not considered best practice, since, for high speeds, it will still be necessary to balance each cylinder by itself and the couple set up axially in the engine, as it were, tends to twist its frame.

In my opinion great credit is due to the firm of Messrs. Belliss, Limited, of Birmingham, England, who many years ago advocated a three crank engine in which the middle cylinder balances the two end cylinders; the latter being both alike. (See Fig. 16.)

Messrs. Belliss, being largely engaged on Admiralty work, may be also considered as pioneers in the application of forced lubrication to High Speed Engines. There are a few explanatory diagrams on the table for which I am indebted to Messrs. Belliss & Co. Single acting engines like the Westinghouse or the Willans Engine, rely on splash lubrication, the crank churning up a lubricating bath and throwing the oil all



over the parts within the engine frame. The lubrication of most High Speed Engines of the open type is effected by means of a central oil reservoir in front of the engine, with as many little pipes, taps and unions as there are points to be reached and to be supplied with oil. Such an arrangement requires constant attention and a tight cap may prevent the lubricant thus fed from reaching the parts that would just require most oil. To effect this lubrication automatically, in the "enclosed" type of High Speed Engine, a pump is arranged within the frame, sufficiently large to flood all the moving parts and surfaces to which it connects by means of suitable links. Fig. 17 shows the usual style of pump for this purpose.

The pressure carried is usually from 15 to 25 lbs. Sometimes, the pump forces into one of the bearings first, the oil rises from there through a hole in the crank pin and shaft up along the connecting rod and to the guides and slippers. (See Fig. 18.)

In another instance (Björnstad's engine), a large distributing pipe is arranged parallel to the shaft, from which distributing pipe little copper pipes branch off and lead to swiveling levers, which latter are hollow, to convey the oil to the cross-head and down the connecting rod, whilst separate pipes go to the bearings. (See Fig. 19.)

To ensure an even flow of oil this engine is also equipped with a little weighted accumulator, blowing off, should the pressure rise unduly. In all these self-lubricating engines the oil goes through a strainer first into a receptacle from which the pump draws. With forced lubrication there is actually always a film of oil between the shaft and the bearing, so that wear is almost imperceptible and such double acting engines, requiring but little attention, may be run much quicker than those relying on gravity lubrication.

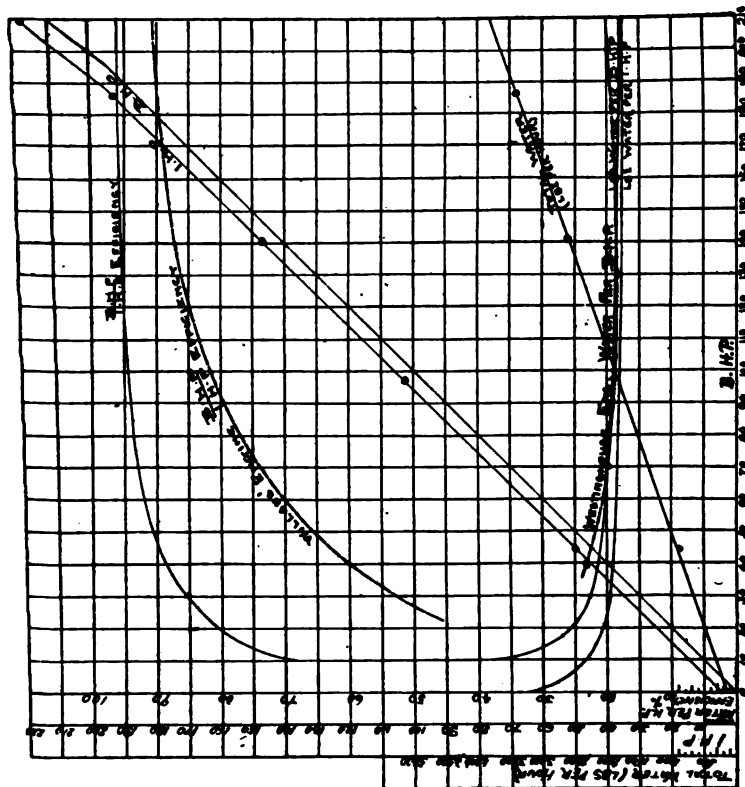
Some people, it appears, contend that lubrication of the steam cylinders is not necessary, but the majority is still in favor of a copious lubrication of all the wearing parts of an en-

LBS. WATER PER H. P. HOUR.

I. H. P.	Water.	B. H. P.	Water.
217.8	17.34	210	18.
207.8	17.5	200	18.2
197.3	17.55	180	18.3
187	17.6	160	18.4
176.8	17.7	140	18.5
166.8	17.8	120	18.6
156.25	17.91	100	18.7
146	18.05	80	18.8
135.8	18.25	60	19.0
125.5	18.57	40	20.36
115.2	19.	20	21.5
104.9	20.6	10	23.76
94.6	33.		34.

TOTAL WATER. EFFICIENCY.

B. H. P.	I. H. P.	B. H. P.	I. H. P.
210	217.8	210	98.4
200	207.8	200	96.25
180	197.3	180	96.1
160	187	160	95.9
140	176.8	140	95.4
120	166.8	120	95.
100	156.25	100	94.5
80	146	80	93.5
60	135.8	60	92.
40	125.5	40	88.75
20	115.2	20	80.
10	104.9	10	66.75



Quick Revolution Steam Engines.—Trial made by Prof. Kennedy, No. 497 D. E. (Sunderland, E. I.)

Broken line shows Westinghouse water per B. H. P. and Williams I. H. P. efficiency as reported in Minutes of

Proceedings of Institution of Civil Engineers, Vol. CXIV.

TOTAL WATER.

E. H. P.	Throttling. Lbs. Water.	Expanding. Lbs. Water.
213	4473 per h'r.	4579 per h'r.
180	3886 "	3940 "
150	3306 "	3370 "
120	2760 "	2815 "
90	2240 "	2400 "
60	1640 "	1820 "
30	1075 "	1200 "
0	520 "	1050 "

LBS. WATER PER I. H. P.

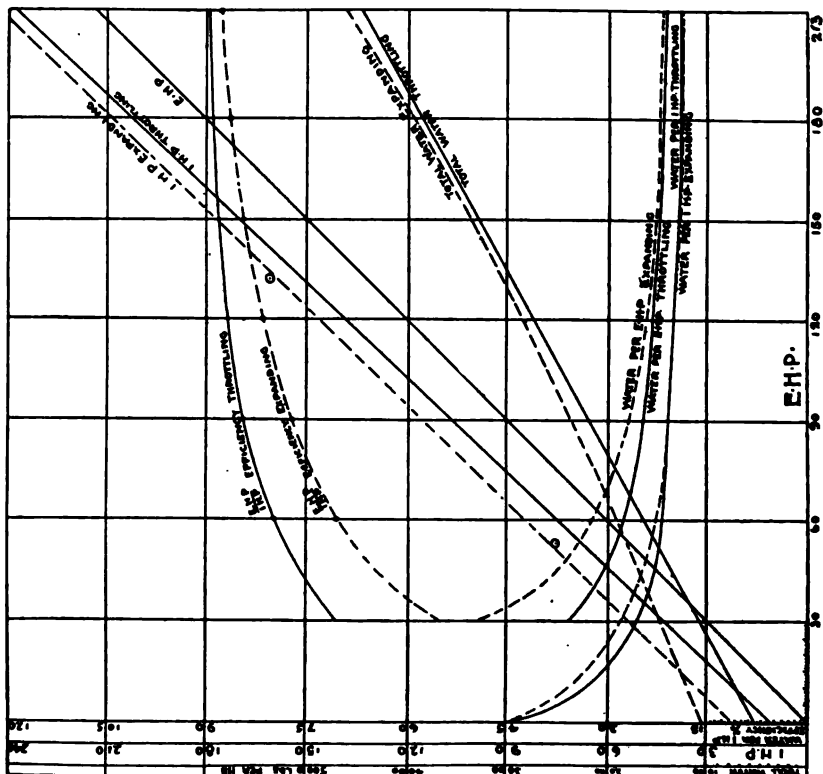
E. H. P.	Throttling. I. H. P.	Expanding. I. H. P.
213	237.5	242.5
180	202.5	208.
150	170.5	177.5
120	138.	147.
90	106.	115.75
60	76.	86.
30	42.5	54.
0	11.	23.

E. H. P. EFFICIENCY.
I. H. P.

E. H. P.	Throttling. I. H. P.	Expanding. I. H. P.	Effic. %
213	237.5	242.5	87.8
180	202.5	208.	86.5
150	170.5	177.5	84.5
120	138.	147.	81.6
90	106.	115.75	77.7
60	76.	86.	70.6
30	42.5	54.	55.3

LBS. WATER PER E. H. P.

E. H. P.	Throttling. Lbs. Water.	Expanding. Lbs. Water.
213	21.	21.5
180	21.3	21.9
150	22.	22.4
120	23.	23.9
90	24.4	26.6
60	27.4	30.6



Bellis Self-Lubricating Engine, E. C. 10 Size.
Curves showing results of Comparative Trials, Throttling and Expanding.
1 (broken line) with Expansion Governor in Action, i. e., Expanding.
2 (solid line) with Expansion Governor out of Action, i. e., Throttling.

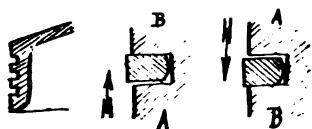
gine and to effect same with the best of mineral oil, which will not carbonize or leave a deposit on the lubricated parts. The mechanical efficiency of engines fitted with automatic pressure lubrication is in spite of the high rotational speeds, very great, reaching the figure of 96 %, whilst 92 % efficiency is commonly attained.

DISCUSSION.

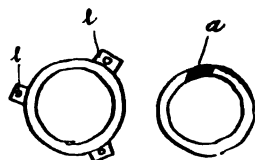
MR. RICHARD HIRSCH—I would be pleased to have you explain a little more fully the valves not having any packing, just the grooves ; are they entirely satisfactory ? Do you not have considerable trouble from leakage ?

MR. HERSCHMANN—From my experience, I am led to consider a plain valve to be quite satisfactory, if there are spring relief valves on the cylinder. I do not think that packing will improve the average piston valve. Of course, when the valve gets out of order, or out of its proper alignment, then it is probable that a packed valve may reduce leakage ; but this state of affairs could not prevail if the design of the valve be on the lines before discussed. I am aware that in my opinion that a liner is not required for the valve to run in, I am at variance with other engineers ; but I think that if the valve is ground in and well lapped, there will be no serious signs of wear for many years.

MR. CHESTER B. ALBREE—Please explain a little more fully the packing of the piston and how these rings are made.



Ramsbottom Rings.



Cast Iron Rings.

MR. HERSCHMANN—The packing of these pistons is usually effected with so-called “Ramsbottom” rings, narrow steel rings fitted into suitable grooves turned in the piston, which

latter is generally cone-shaped, to give it more resistance and facilitate drainage. Messrs. P. R. Jackson, Limited, of Manchester, England, are the original makers of these Ramsbottom rings, and they shape their sections as I show on the sketch, rounded off on the inside to facilitate handling.

As a rule two or three narrow rings are fitted and give excellent results; they are so arranged as to "break joints," and little pegs are inserted where they are split to keep them in their positions, relative to each other, and prevent scoring of the cylinder. The piston should be provided with a very broad face. They will, for various reasons, be often found with a narrow face. The rings must not fit too well, or else the steam will not have a chance to get at their side (on the steam side of the cylinder), which I mark with the letter A, to press the rings against the exhaust side, B. Cast iron rings are also used, and the latter are made from a specially cast hollow cylinder, which I will outline on the blackboard with lugs, "I" to clamp it to a face plate and slice it into narrow rings. From these rings a portion is afterwards removed, so that when they become again sprung together they will be oval. They are then turned around to a diameter just the bore of the cylinder, so they will be springy and "pack" when released.

A MEMBER—Can these rings be made for any diameter?

MR. HERSCHMANN—The minimum diameter I should call about 4 or 5 inches, in fact that of the smallest solid piston over which it will be possible to slip and introduce the rings into their grooves and the smallest diameter of such rings of which they can be made so as to have enough spring to effect a packing. For a piston of say 3 foot diameter, or more, I should consider another design of rings for similar reasons.

MR. RALPH CROOKER, JR.—In comparing the two cylinders, the long stroke and small diameter, and the short stroke with the large diameter, do I understand you to favor the large diameter? With the large diameter you must have valve areas large enough for the steam cylinder to get the steam in quick.

Now when you compare the area in that valve, would not the comparison be in favor of the long stroke?

MR. HERSCHMANN—The comparison was only made to show that short stroke calls for a large "cut off," and I think you will find that I stated the actual conditions are more in favor of the long stroke, as far as condensation is concerned, if we consider the unusually large port areas of short stroke engines. Whether to favor the long or short stroke engine will have to be decided on the merits of every individual case, where an engine has to be installed. Generally speaking, this is a question which will be more affected by commercial and general considerations than by those of a purely technical nature.

MR. SNYDER—Do I understand that it is modern European practice to do away with the automatic cut off?

MR. HERSCHMANN—In speaking of European practice, we mean English and Continental designs of engines. While on the Continent of Europe automatic governing is very much in evidence, it is the English practice, at least that followed by the prominent makers of quick running engines there, to employ throttle governing almost exclusively. The tendency is, as far as central stations are concerned, to fix on the certain size of unit most suited for the case and to aim at a high "load factor," and as much as possible constant load. The engines, in general, are not as big as those used in this country, though a few monster engines were tried in England some years ago, which were then the biggest of their kind, to furnish power for electric light.

Meeting adjourned at 10.30 P. M.

REGINALD A. FESSENDEN,
Secretary.

MEETING OF THE CHEMICAL SECTION.

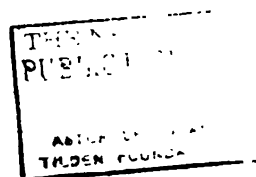
PITTSBURG, April 20, 1899.

The regular monthly meeting of the Chemical Section for April 20th, 1899, was conducted informally at the rooms of the Society.

No business was transacted and no papers were read.

Those present discussed informally recent chemical literature and separated about 10 P. M.

A. G. McKENNA,
Secretary C. S.



ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA,

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The one hundred and ninety-fifth regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the Society's House, 410 Penn Avenue, Pittsburgh, Pa., Tuesday evening, May 16, 1899, forty members and visitors being present. The minutes of the preceding meeting were read and approved.

For the Board of Directors the following applicants were reported as passed and to be voted upon at the next regular meeting :

SEWARD BABBITT,	-	Salesman for Wm. Tod and Wm. B. Pollock & Co., of Youngstown, Ohio, 1217 Park Bldg., Pittsburgh, Pa.
DAVID F. CRAWFORD,	-	Assistant Superintendent, Motive Power Penn'a Lines West of Pittsburg, care Penn'a Co., Ft. Wayne, Ind.
GEORGE A. GILFILLAN,	-	General Engineer, 341 Fourth Ave., Pittsburgh, Pa.
DAVID S. KENNEDY,	-	Superintendent, Rolling Mills, Homestead Steel Works, Munhall, Pa.
FRANCIS H. KNOX,	-	Electrical Engineer, Charleston City Railway, Charleston, S. C.
JOSEPH M. NESBIT,	-	Attorney-at-Law and Solicitor of Patents, 705 Park Bldg., Pittsburgh, Pa.

The following gentlemen were balloted for and duly elected to membership :

CLIFFORD G. DUNNELLS,	-	Assistant Engineer, with the Pittsburgh Bridge Co., Pittsburg, Pa.
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202 ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

EDWARD F. AUSTIN,	-	Representing Stillwell, Pierce & Co., and Smith Vial Co., Dayton, O. Room 203 Smith Block, Pittsburg, Pa.
ROBERT GEDDIS,	- -	Salesman, with Jones & Laughlins, Limited, Pittsburg, Pa.
HUGO J. GLAUBITZ,	-	Mechanical Engineer, with Julian Kennedy, Pittsburg, Pa., Clayton Ave., Allegheny, Pa.
WILLIAM H. GOULD,	- -	Assistant Engineer, with Pittsburg Bridge Co., Pittsburg, Pa.
ALFRED N. SPENCER,	-	Chemical Engineer, with Hyde Bros. & Co., 902-3 Lewis Block, Pittsburg, Pa.
ADAMS PLUMMER TANNER,		Mechanical Engineer, with Julian Kennedy.
LAWRENCE R. WHITE,	-	Manager, Pittsburg, Office Frick Co., Waynesboro, Pa., 51 Schmidt Building, Pittsburg, Pa.

It was moved that a committee of four be appointed to draw up a memorial on the death of Capt. Hunt. The chair appointed the following gentlemen: Messrs. Davison, Davis, Clapp, and Col. Roberts.

The thanks of the Society were voted to the Westinghouse Co. for the photographs furnished for the Society's rooms.

It was voted that arrangements be made by the Reception Committee for an excursion of the Society this summer.

It was suggested by Mr. Schellenberg that the Society join with the Central Mining Institute of Western Pennsylvania in their steamboat excursion in July, on the 11th probably.

The paper of the evening, entitled "Pittsburg, With Its Black Diamonds," was then read by Mr. A. P. Kirtland.

PITTSBURG, WITH ITS BLACK DIAMONDS. ✓

BY A. P. KIRTLAND.

Secretary Marble Hill Quarry Co.

Some years since, a popular writer of the day, on coming into our city at night over the Pan Handle Railroad, and witnessing stack after stack belching forth volumes of smoke and fire, said Pittsburg was "Hell with the Lid Off."

While the expression may strike one as "more forcible than elegant," underneath it all lies the secret of our city's greatness, for, were it not for this cloud of smoke by day and pillars of fire by night, a very different story would be written all over these hills. Strangers, as a rule, on making their first visit here are not slow in remarking these features we have ever present with us, and sometimes express wonder at our being able to exist in them; but, on further acquaintance, they realize that it is smoke that makes Pittsburg the great city it is.

Rear Admiral Schley, who, through the smoke and din of battle, wrought such changes in a few minutes in our nation's greatness at Santiago, when our guest here recently, said of our city, "Her Smoke is her Glory." He realized, as do our citizens, that Pittsburg would not be Pittsburg without it, and hence to be called the "Smoky City" causes no feelings of resentment in us.

What it might mean to this location was foreseen away back in its early history by another of our greatest countrymen, and an engineer.

On November 23d, 1753, George Washington arrived, under orders from Governor Dinwiddie of Virginia, to establish a fort at the junction of the Allegheny and Monongahela rivers. He wrote in his diary on viewing the territory embraced in the Forks, "This would be a good place for a mill." He did not say what kind of a mill, it was not necessary, for to-day Pittsburg and its river fronts, for over twenty miles, are literally crowded with mills of every description.

But something other than sites are needed in operating mills and other vast industries, the prime requisite being cheap fuel, and in this we discover the true secret of the city's rapid growth. Underlying these hills in every direction are stored veins of a superior quality of bituminous coal, in almost inexhaustible quantities. In fact, within the last few weeks, some of it has caught fire on Wylie avenue, causing a miniature volcano underneath the very houses.

The distribution of what is called the Appalachian field of bituminous coal, which furnishes about two-thirds of all the output is said, by reliable authorities, to be, according to their rank in the holding of coal territory, as follows, viz:

STATES.	SQ. MILES.
1. West Virginia,	17,000
2. Pennsylvania,	12,300
3. Ohio,	10,000
4. Kentucky,	9,000
5. Alabama,	6,000
6. Tennessee,	5,000
7. Virginia,	1,000
8. Maryland,	550
9. Georgia,	170
Total area,	61,020

from which you will note Pennsylvania stands second on the list. While the coal all through this basin is usually a coking coal, as pointed out by Rogers many years ago, these coals increase in bituminous matter as they go westward, so that the coal in the Pittsburg seam, which in Cumberland has only some eighteen per cent. volatile matter, contains thirty per cent. in the Connellsville region, thirty-two to thirty-five per cent. in Pittsburg, and thirty-five to thirty-eight, and even forty per cent. in Ohio. The veins also thin out as they go westwardly, which makes the mining more expensive.

Referring to the example already given, the Pittsburg vein, which is the big vein at Cumberland, is sometimes four-

teen feet; in Connellsville nine feet; in Pittsburg five to seven feet, and in Ohio two and one-half to four feet. Where the veins are thin the percentage of ash, and especially the percentage of sulphur, is apt to be much higher than in the thicker veins.

For all these reasons, as stated above, the coals in the middle and western part of the Appalachian basin as a rule are not so good as those closer to the mountains. Practically all the coal mined in the Monongahela Valley is from the Pittsburg seam of coal, this being the chief seam in the upper productive measures.

When the late Prof. Rogers was making his well known survey of the State of Pennsylvania, the Pittsburg seam and its associated strata were displayed to such advantage along the Monongahela river that in his geology these coal measures, including the Pittsburg seam, are called the Monongahela River Series.

Speaking of this bed, Prof. I. C. White, in his report on the bituminous coal fields of Ohio and West Virginia, says: "It is the most important mineral deposit of the Appalachian field." Speaking of the importance of these coal measures, Prof. Leslie says: "If its underground constitution (that is, the strata in the neighborhood of Pittsburg) were not carboniferous, the City of Pittsburg, with its surrounding towns and villages, mines, mills and furnaces, dams, pools and steamboats, fleets of barges, trains of railroad cars, oil well derricks and gas pipe lines, would be simply a poet's dream, and not the great reality in which its people glory." He speaks of its wealth of coal as absolutely inexhaustible for several thousands of years, and states that the exhaustion of the mineral coal of this region is a practical impossibility.

Of the value of its coal he also says that it depends, (1) on the superior quality of the coal, (2) on the unlimited quantity of it within easy reach, (3) on the exceptional facilities offered by the geological structure in mining operations, but not on the size of individual coal beds. The size of the coal beds in the



Pittsburg region is by no means remarkable. At Pittsburg it is about six feet, and it may be said to vary from this to twelve feet. The quality of the coal is stated to be "A-No. 1," and what is of great importance, the Pittsburg beds along the Monongahela river can be opened in hundreds of collieries along both banks of the river for many miles, and in all their valleys and ravines.

Prof. Leslie estimates that the zigzag outcrop of this coal is not less than two thousand miles, and this great bed lies mainly above drainage level.

It is from this bed along the Monongahela and Youghiogheny rivers that the well known gas coals, used so extensively in the gas works of the United States, are mined, as well as the the well known Pittsburg steam, domestic and industrial coal, and the coal that makes the well known Connellsville coke. This coal bed extends the entire navigable length of the Monongahela river, being cut out at points, and of less value for certain purposes in parts of the river than in others.

Below find a statement of all coal shipments through the Monongahela Locks since their completion, November, 1844, to the present time, showing an increase from 4,665,185 bushels in 1845, to 148,956,860 bushels in 1898, about twenty-five per cent. of which was used in this city.

YEARS.	BUSHEL OF COAL.	YEARS.	BUSHEL OF COAL.
1844	737,150	1872	54,208,806
1845	4,665,185	1873	56,073,238
1846	7,778,911	1874	65,881,700
1847	9,645,127	1875	61,409,000
1848	9,819,361	1876	62,395,000
1849	9,708,507	1877	79,480,918
1850	12,297,967	1878	76,825,255
1851	12,521,228	1879	65,588,000
1852	14,630,841	1880	89,377,150
1853	15,716,367	1881	90,035,360
1854	17,331,046	1882	106,168,300
1855	22,234,009	1883	112,395,389
1856	8,584,085	1884	81,709,852
1857	28,873,596	1885	85,923,107
1858	25,696,669	1886	113,099,147
1859	28,286,671	1887	78,912,900
1860	37,917,732	1888	115,814,900
1861	20,865,722	1889	81,162,500
1862	18,583,858	1890	116,902,600
1863	26,454,252	1891	106,914,700
1864	35,070,917	1892	96,818,350
1865	39,522,792	1893	96,501,000
1866	42,615,300	1894	116,240,313
1867	30,072,700	1895	104,589,900
1868	45,001,000	1896	142,731,300
1869	52,512,600	1897	137,535,788
1870	57,596,400	1898	148,966,860
1871	48,621,300		

While some of the coal in the Connellsville district was manufactured into coke before the sixties, it was not until after the Civil War that this product played any considerable part in the manufacturing of iron. Since that time, however, it has been estimated that a product worth \$150,000,000 has been taken from the string of mines between Latrobe and Oliphant. This district still remains the most important coke producing center in the United States, and one of the most important in the world. This coal basin is some thirty to forty miles from Pittsburg. According to a recent topographic survey made by Mr. Kenneth Allen, Civil Engineer for the H. C. Frick Coke Company, the basin has a length of 43.6 miles and an average width of 3.1 miles, or an area of 137 square miles. This entire

territory is supposed to be underlaid with the Connellsville seam of coal, which is without fault; it is claimed, the beds yielding from six to ten feet of workable coal. On the basis of 137 square miles there would be 87,680 acres of coal. There is not this amount now, however, as considerable of it has been worked out.

It was estimated that the amount of coal land still remaining in 1897 was somewhere about 60,000 acres, which, at the usual average of this coal per acre, would leave about 450,000,000 tons of coal still available in the Connellsville vein.

From a few hundred ovens in 1870, the field has grown to nearly 19,000 now. In 1880, which is but eighteen years ago, the total amount of coke made in the region was 2,205,946 tons; last year it was 8,460,112 tons, an increase of nearly 400 per cent., an average increase of 22 per cent. for each year over the output of 1880. The coke region was never so prosperous. Last year the sale of coke brought the makers over \$13,000,000. The best revenue prior to that was \$12,540,000 in 1890, but that was when coke sold for much more money, and it represented an output of about one-fourth less. Last year was the greatest known; this year it is running greater, for more ovens are in blast.

March report showed coke shipments running about 9,800 cars weekly; that rate continued through the year would give an annual product of some 490,000 cars, which exceeds the high record of last year, when the shipments were 441,249 cars.

In a recent interview with one of the leading men of the Monongahela Valley, he said, 'This is destined to be the factory of the world. I make a prediction that ten years from now the amount of Monongahela coal that goes below Pittsburgh will not be worth considering. The growing trade of Pittsburgh and the vicinity will take all that is offered. Have you any idea of what a quantity of coal is required for Pittsburgh's mills? Jones & Laughlins are one firm having its own supply of fuel in the valley. It is said that they take each year about



13,000,000 bushels of Monongahela coal; what the Carnegies require can be guessed at from that, but I presume it is not less than 20,000,000 bushels, and perhaps more; these are but two concerns. Pittsburg is full of establishments that are eating into coal in a similar way, but that is not all, new mills are building right along, and from year to year new concerns are coming into the valley between Pittsburg and Brownsville. As you pass down the river you notice the new plants that have been built in a few years all along the line.

New towns are arising about the plants; here is the fuel, and here the manufacturing will be done."

In this connection it must not be forgotten that there are very valuable coal fields along the Allegheny Valley as well. It will doubtless be a surprise to many, even in this city, to learn that we have a field of coking coal along this valley whose southern boundary reaches to the very door of our city, the extent and quantity of which bids fair to rival the famous Connellsville coke region. The question which would naturally follow such a statement is, why, if such be a fact, has it not been operated ere this? The answer is, that it was not known to exist at the time the state geologists published their report on the coal in this section, and, furthermore, a good quality of merchantable coal occurs near the tops of the hills, or between four and five hundred feet above the coking vein, where it could be operated without shafting. Nature has been so lavish with her bestowal of means for wealth, in this part of the state, that time alone can develop all she has in store for us. This vein was reached, however, by a ninety foot shaft just above Verona, back about 1861, and operated for some two years, the product coming to mills here in the city.

The erections at the shaft caught fire accidentally and were burned down. As a great scarcity of cars existed at the time the works were not rebuilt, the shaft was allowed to fill up, and it has not since been operated.

The thickness of the vein was found to be about seven feet, and quite uniform, and an analysis by Otto Wert showed, from three specimens, as follows :

	SPECIFIC GRAVITY.	ASHES.	CARBON.	RELATIVE VALUE OF COAL, PURE CARBON 100.	COKE.
Specimen 1.	1.3138	7.34	79.31	87.3	67.45
“ 2.	1.2932	5.32	81.32	88.7	63.50
“ 3.	1.2921	3.64	83.14	90.04	63.10

“Neither of these samples contain sulphur or phosphorus. the ashes consist of silica and alumina, with traces of lime and iron,” thus indicating its coking properties, but, as the use of coke was in its infancy at that time, its value was not considered from that standpoint.

In recent years the extent and continuity of this field has been very thoroughly tested by numerous holes drilled all over it for gas and oil, and its coking properties, as well, definitely ascertained by the sinking of several diamond drill holes at points several miles apart, and a shaft near the center of the field.

The results go to establish the important fact that we have, at our very door, a basin of coking coal some six or seven miles wide along the Allegheny River, ten or more miles long, extending eastward beyond the Murrysville branch of the Pennsylvania Railroad, embracing over 60,000 acres of continuous coal, or a field equal in size to that of Connellsville, and, that the analysis and thickness of the vein, six to eight feet or more, indicating it is not the Freeport vein, as some have supposed (which is about a three and one-half foot vein, and shows much less carbon and more sulphur) but has great similarity to the Connellsville basin.

Furnace people who have coked it by the carload, and tested it recently, have borne testimony to this similarity and of their willingness to use it when developed. And an expert who operated in the Connellsville region before the “bee hive” oven

came into use and has ever since, after examining the field and having some of the coal coked and analyzed, says, "In my judgment this coke would rank with the average Connellsville coke, some portions of the Connellsville vein showing lower in sulphur and phosphorous and other portions showing considerably higher."

We give below several analyses of the coal and coke recently made.

COAL.

BY WHOM ANALYZED.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Phosphorus	Moisture.	Percentage of Coke.
Wuth & Stafford	35.470	57.628	5.060	0.915	0.012	.915	63.614
Philadelphia Commercial Museum	33.800	61.111	3.275	0.828	.....	1.400	.....

COKE.

1. Wuth & Stafford for Expert	.32	89.94	8.68	1.04	.025	.....	.....
2. Wuth & Stafford for Expert	.29	89.85	8.57	1.27	.019	.....	.....
Isabella Furnace Co.	.....	.....	10.20	1.01	.020	.....	.....
Another Large Furnace Company	2.410	87.71	9.88	1.24	.036	.....	.....
F. T. Ashman & Co.	1.88	85.37	12.38	1.17	.009	.....	.....

With the river now being slackwatered along side of this coal field, and the Allegheny Valley Railroad and Plum Creek branch, and the Pittsburgh, Bessemer & Lake Erie Railroad running through it in various directions, its value to "Greater Pittsburgh" can more readily be imagined than described. And the prophecy above made for the Monongahela Valley can be extended, as well, to the Allegheny and Ohio Valleys. To give a faint idea of what they now contain, a statement made a few days since of one company, the Carnegie, shows it now owns and operates in them the following plants: "Edgar Thomson furnaces, Bessemer, producing 1,000,000 gross tons yearly of pig iron, spiegeleisen and ferro-manganese; Duquesne furnaces, Duquesne, producing 750,000 gross tons of bessemer and basic pig iron yearly; Carrie furnaces, Rankin, producing 250,000

gross tons annually of bessemer, basic and special iron; **Lucy** furnaces, Pittsburg, with an annual capacity of 250,000 gross tons of bessemer, basic, forge and foundry pig iron; **Edgar Thomson Steel Works**, Braddock, producing 600,000 gross tons annually of bessemer steel rails and billets; **Duquesne Steel Works**, Duquesne, producing 450,000 gross tons annually of bessemer steel rails, billets and splice bars; **Homestead Steel Works**, Munhall, producing annually 400,000 gross tons of bessemer steel and 850,000 gross tons of open-hearth steel, including plates, beams, channel and other structural steels, armor plate and forgings; **Upper Union Mills**, Pittsburg, producing 215,000 gross tons annually of plates, bars and structural steel; **Lower Union Mills**, Pittsburg, producing 80,000 gross tons annually of plates, bars, forgings and structural steel; **Keystone Bridge Works**, Pittsburg, producing 50,000 gross tons annually of bridge, elevated railroad and structural steel. The limited partnership also owns the **Larimer Coke Works**, Larimer, Pa., and the **Youghiogheny Coke Works**, Douglass, Pa., 375 coke ovens in all.

The allied organizations, including among others, the **Pittsburg, Bessemer and Lake Erie Railroad Company**, the **Union Railroad Company** and the **H. C. Frick Coke Company**, the property of the latter including 39,002 acres of **Connellsville** coking coal and 21,377 acres surface in **Fayette** and **Westmoreland** Counties. The coke works comprise about 12,000 ovens, 3,325 tenements, and other improvements."

Perhaps, in closing this paper, the greatness that has, and is yet destined to come to Pittsburg from her inexhaustible wealth of coal, cannot be more forcibly placed before you than to quote from the recent startling speech of our representative, **Hon. Wm. H. Graham**, delivered at Washington, on the **River and Harbor Bill**, in which he said :

"Mr. Chairman:—Some criticism has been made at to the large amount appropriated in this bill for the improvements of the **Monongahela**, **Allegheny** and **Ohio** rivers, including this

[illegible]

-- Within a radius of 100 miles according to the last census, there is a population more than Chicago and a number of hospitals, a capital, surplus and very few...

"Of the following products
Allegheny County produces
the following:

Plate Glass
 Pig Iron,
 Window Glass,
 Table Glassware,
 -- Has 2 1/2 mile and 1/2 mile of water, with
 a capital of over \$200,000, and is the largest
 \$244,500,000, paying out a wage of \$20,000,000
 Has 112,000,000,000, and 10,000,000,000,000

000 workers. Also over 250 miles of electric street railway, with combined capital of \$54,000,000. One thousand miles of iron pipe is used in conveying natural gas to the manufactories and dwellings. Pittsburg stands sixth among the cities of the United States in comparative volume of bank exchanges. Pittsburg coke district produces sixty-five per cent. of the entire output of coke in the United States; Pittsburg oil district produces sixty per cent. of the entire output of oil in the United States. The daily output of coke if loaded on one train, would be ten miles long, and yet, notwithstanding this immense product, surveys show 75,000 acres of coking coal yet untouched in this section. The above figures only show a few of the leading industries that far surpass those of other sections, but, in addition, there are hundreds of other lines of manufacture which I have not the time to dwell upon. While Pittsburg is famous the world over as the manufacturer of the most unyielding products of man's labor, namely, iron and steel, yet it stands first in the manufacture of glass, that most brittle article of trade.

“Pittsburg can present annually to every man, woman and child in this country, a glass bottle. (Laughter.) It leaves to them to decide whether it shall be filled with milk or something stronger. (Laughter.) I can give you a pointer that she sends out with the bottles 20,000,000 glass tumblers annually. And while I do not claim that Pittsburg leads the country in the manufacture of rye whiskey and beer, she makes enough beer and whiskey to fill all the tumblers she sends out, her most recent product being a \$25,000,000 beer syndicate.

“Now, to provide for other cravings of the stomach, she has the “Heinz” firm, which sends out pickles enough to present every human being on the face of the earth with one. Of course, she manufactures corks enough to safely preserve the contents of all her bottles. (Laughter.)

“One point I wish to bring out is the fact that the tonnage, river and rail, of Pittsburg exceeds the river and rail tonnage of any other city in the known world. The river and rail ton-

nage of Pittsburg will amount to one-half as much as the combined commerce of the Atlantic and Pacific coasts. Now that is a startling statement, but it is true nevertheless. If you take the entire commerce of New York, Baltimore, Boston, and the Pacific coast, the tonnage of all the vessels entering and leaving these ports will only exceed the tonnage of Pittsburg by one-half.

“She has a railroad tonnage greater than any other city in the world. Her railroad tonnage is three times that of New York or Chicago, twice that of London and four times that of Paris. (Applause.) Imagine a railroad tonnage in excess of the combined rail tonnage of New York, Chicago and Boston. Two hundred and fifty passenger trains enter and depart daily from Pittsburg.

“Including the Connellsville coke region, over 2,000,000 railroad cars are loaded annually.

“The trade of a single firm in this city, in iron ore, limestone, fuel and finished product, amounts to a greater tonnage than the combined cotton product of the entire Southern States.

“Allegheny County consumes, during the winter months, over 1,000,000 cubic feet of natural gas per day. This is a greater consumption than at any previous time since the discovery of natural gas, and certainly does not indicate that the supply is becoming exhausted.

“It reads like a paradox, that Pittsburg, known as the Iron City, and making more iron than any other city on the globe, has no iron ore mined within 250 miles of its borders, the rough material being transported mainly from northern Michigan, it being found cheaper to transport the ore to the fuel than to bring the fuel to the ore.

“Now, here is something that will perhaps interest gentlemen as to the revenue received by the United States from this section. The report of the Commissioners of Internal Revenue shows that of the 114 revenue districts in the United States there are only seven which exceed this, the twenty-first district

of Pennsylvania, in gross receipts, the returns for the last six months being \$4,209,233.95, indicating an annual increase of \$10,000,000 from this district. (Applause.)

“Now for comparison with the world. Pittsburg contains the largest Bessemer steel plant in the world. It contains the largest Crucible steel plant in the world. It contains the largest Plate-glass plant in the world. It includes the largest Chimney-glass plant in the world. She manufactures enough glass chimneys to break three or four in every family every day. It includes the largest Table Glassware plant in the world. It includes the largest Air-brake plant in the world. It includes the largest Steel Rail plant in the world. It includes the largest Pickle works in the world. (Laughter and Applause.) It includes the largest Cork works in the world. It includes the largest Tube and Pipe works in the world. It includes the largest Steel Freight Car works in the world, and includes the largest Coffee-roasting establishment in the world. Gentlemen, if I had time I could tell you hundreds of other things that Pittsburg contains.” (Laughter and Applause.)

It is hardly necessary to add, that after Mr. Graham concluded his very able presentation of Pittsburg's greatness and corresponding needs, his time for same having been extended by unanimous consent of the House, he carried his point: Ayes 106, Noes 1.

My apology for having used so much of his thunder in presenting the subject before us, is, that I knew of no more concise way to bring before your “mind's eye” the greatness that has, and is yet, to come to Pittsburg from her exceptional wealth of “black diamonds.”

DISCUSSION.

Mr. Schellenberger asked for some information about the new coal vein. What part of the rock measures does it occur in?

MR. KIRTLAND—It may belong to the Barren Measures. It has been thought by some to be one of the Freeport veins,

but more recent investigations seem to prove otherwise; as the Freeport vein, which runs out at Valley Camp, about a mile up the river from this basin, occurs 110 feet below the level of this vein, is only three and a half feet thick, and its analysis shows it to have much less fixed carbon and much more sulphur and phosphorus than this vein. The analysis of this vein shows its great similarity to the Connellsville basin.

This vein occurs about 500 feet below Pittsburg coal in this locality, and its continuity and thickness has been tested by wells bored for oil and gas; over 300 altogether.

It runs never less than six feet thick, and generally seven. A shaft recently sunk near the center of the field shows six and one-half feet pure coal.

MR. E. K. MORSE—Our consumption in Pittsburg will soon take care of all the coal coming down the Monongahela.

MR. BOLE—There were three kinds of coal mentioned; please explain the difference between them.

MR. KIRTLAND—Steam Coal—Almost any coal that has plenty of carbon in it, and is not high in sulphur and other impurities, comes under this head.

Gas Coal—Coal that has a large amount of carbon and volatile matter is considered most desirable for this purpose.

Coking Coal—Coal that is high in fixed carbon, and especially low in phosphorus, sulphur and ash comes under this head.

MR. BOLE—What is the relative value of heat units in the different kinds of coal?

MR. ALBREE—In this week's Engineering Record was a careful discussion of all kinds of coal.

MR. LEWIS—Also in the experiments of the Ohio State University. We can get them from Professor Lord of Ohio State University.

MR. SCHELLENBERG—That report states that one seam differs from another. I think the difference is more from geographical than from geological position.

MR. LEWIS—I think both have to do with the question.

MR. CAMP—I have made thousands of analyses of Connellsville coke and these show that the coal differs widely from mine to mine.

MR. WILKINS—What amount of ash should coke have?

MR. CAMP—The ideal coke would have no ash.

MR. WILKINS—Is not some ash necessary to hold up the charge in the furnace?

MR. CAMP—It is not so considered. The strength of the Connellsville coke is due to the inherent qualities of the coal.

MR. WILKINS—I have understood that West Virginia coke was too soft as it had only five per cent. of ash.

MR. CAMP—Most any coal coked in by product ovens give excellent results in the furnace irrespective of the amount of ash in the coal.

MR. SCHELLENBERG—The even distribution of the earthy matter through the seam's measures in the Connellsville basin has something to do with the easy making of a coke there of great homogeneity and mechanical strength. In the Pittsburg basin the earthy matter is segregated in thin seams of slate, the binders regularly placed in position in height of breast. The artificial intermingling by crushing the coal before coking, as done by Jones & Laughlins, with the poor coal, improves the uniformity of texture and add to the hardness, while the washing (jigging out of slate) causes the coal to make a softer, weaker coke, although seemingly improved in quality, as having a lower percentage of ash and sulphur. Sometimes we get most sulphur near the top as Freeport seam has it at its crops along the Ridge. Above a hard under-bottom the coal next is sulphurous, and the purest looking Connellsville is found with a pure fire clay bottom that softens on exposure, and therefore a little shell of the very bottom of the coal is left behind in the mining to keep the air from it, and to prevent the consequent giving way of the foundation of the coal pillars, which stand as temporary supports to keep the opening. Whether the hard-

ness of the under-bottom is cause or effect of the purity of the coal seam—whether it has been made hard by the leached out sulphur from above, or is soft because none came or stayed, is not certain.

Sulphur occurs in narrow streaks through the wide territory of our coal seam; in a strip that may be miles long but not many yards wide. None of the basins differ in this being the manner of occurrence of that and other irregularities in quality, while in position the slight folds we meet are likely to be parallel and to run generally between north and east.

MR. LEWIS—The mine superintendents make the excuse for delivering poor coal that the difference is due to taking from the top or from the bottom of the seam, but those who know anything about the matter know that it would cost too much to keep the two separate and that this is not done.

About gas coke, I would say that gas manufacturers sell their coke for a profit so great that it is sufficient to pay all working expense and the cost of the coal, so that it is usual to say that they get their gas for nothing.

The thanks of the Society were voted to the author for his paper.

The meeting adjourned at 9:50 P. M.

REGINALD A. FESSENDEN,
Secretary.

MEETING OF THE CHEMICAL SECTION.

PITTSBURG, May 18, 1899.

The regular monthly meeting of the Chemical Section was held May 18th at the rooms of the Society. Chairman, E. S. Johnson. Attendance, 13.

The minutes of the March meeting were read and approved.

Dr. Stahl reported that if the Section wished, arrangements could be made to visit the Phoenix or Wainright brewery. On motion of Mr. McKenna, it was resolved that the time for the visit be set for the evening of June 29th.

Mr. Peters read the paper for the evening on a "Suggested Improvement in the Manufacture of Wrought Iron." The paper was discussed by Messrs. Johnson, Camp, Mohr, and others. Section adjourned at 10 P. M.

A. G. McKENNA,
Secretary C. S.

SUGGESTED IMPROVEMENTS IN THE MANUFACTURE OF BAR IRON. ✓

BY SAMUEL PETERS.
Pittsburg Reduction Co., New Kensington, Pa.

Soft steel or ingot iron, has for many purposes and to a large extent, replaced ordinary wrought or weld iron during recent years. Notwithstanding this, there is a demand for good wrought iron produced by methods analagous to the puddling process, which gave a practically carbonless iron, and which is best defined as weld iron to distinguish the product from that obtained in the form of ingot.

This definition will be recognized as one that was advanced about the year 1876, and one that is in use chiefly on the Continent of Europe.

I believe that all will agree that there is a genuine

demand for weld iron, as shown by a frequent perusal of the iron trade papers. Until within a few years very much weld iron has been produced by reworking scrap wrought iron. The quantity so produced is now much less on account of the difficulty in obtaining wrought scrap unmixed with soft steel. On this account and on account of the ever-growing demand for cheapening product and at the same time improving the quality, any method that will economically produce these desirable results is worthy of attention.

The bulk of the "new iron" is produced in this country in the puddling furnace, and roughly speaking, the method, as well known, consists in oxidizing the silicon, carbon, sulphur and phosphorous.

The iron given to the puddler may, and frequently does, vary much in composition, so that to make sure of good results, a large excess of iron ore and iron cinders is used. This excess is chiefly obtained from the oxide of iron, lining the boshes, and which keeps the cinder added and formed in the reactions basic in character. This variation in the composition of the pig iron demands skill and experience on the part of the puddler to produce good results, his chief guides being the relative fusibility of the iron, the kind of cinder produced, and the nature of the reactions occurring in the furnace. Irons high in silicon, say $2\frac{1}{2}\%$ to 3% , and high in phosphorus, say $1\frac{1}{2}\%$, are difficult to deal with by this process. Theoretically this should not be a difficult matter, for if the composition was known, the cinders added could be chosen, and one low in silica used. That this can be done, I can vouch for by an experience I once had with a high silicon and high phosphorus pig iron. The pig was melted along with rich iron scales, containing practically no silica. As soon as the iron and scales were melted the liquid bath was rabbled for a very short time, and the cinder was at once run off. When this was done a lot of iron cinder containing considerable silica (and which had been previously piled on the ore lining in a large

bunch, so as to prevent much of it melting), was pulled into the bath and melted, and the heat finished with this cinder slightly acid in character. The results were very good indeed. If rich iron scales containing no silica are used entirely, and with a low silicon pig, the cinder retained by the iron will be so basic as to fuse with difficulty on reheating the muck bar, and produce a hot short or slag short iron. The quantity of cinder employed is important, as will readily be seen from a chemist's standpoint. It is also quite as important from a physical standpoint. There is a limit to the quantity of cinder that should be present. If too much be present the early stage of the operation is retarded on account of the large quantity of cinder hindering the iron from obtaining the necessary heat from the flame. This, however, rarely happens. If too little cinder is present the dilution of the impurities conveyed from the pig to the cinder is insufficient, so that a more impure cinder will in that case be carried into the puddled ball. Again, too little cinder present will retard the refining and hence the welding of the granules as they are formed, or when the iron is "dropping"; at that time the cinder is collecting on the bottom of the furnace, and still needed to further decarbonize a portion of the iron not then wholly refined. In practice with the ordinary puddling furnace it is found, as a general rule, when working grey forge iron, that 500 to 600 pounds of iron ore are required per ton of muck bar, although in many cases the amount of ore will run up to 1,000 lbs. per ton of finished muck bar, exclusive of taps and of squeezer cinders added. From a consideration of the foregoing, would it not be well if a more scientific method of dealing with the materials at command could be used? Attempts have been made in this direction, as witness the following brief description of a method once used, although not in use now so far as I am aware:

A good brand of mill pig iron was melted in a cupola, then transferred to an acid Bessemer converter and there "blown" until the silicon had disappeared and the carbon was reduced

to a comparatively small percentage. The melted metal was then transferred to a properly heated Balling furnace or to a Danks rotary furnace lined with iron ore, and there further treated until the metal dropped or came to "nature." The resulting ball or bloom was squeezed or hammered and rolled into muck bar. The product thus made I was told was excellent in quality under cold test. Why the method is not in use now I do not know, unless it is that the metal produced cost too much, or was red-short; one would expect it to be the latter, judging from the character of the lining of the furnace. It would seem to the writer that the following method will accomplish the results already pointed out as desirable to be obtained. The method here proposed is not in use, so far as I am aware. Melt the pig metal to be treated in a cupola, then transfer it to an acid Bessemer converter, and when desiliconized and mostly decarbonized by the usual means, transfer the liquid metal to a properly heated rotary furnace lined with bauxite or magnesite, either in the form of brick or as a monolithic lining. The carbon and phosphorus present, it is proposed, shall be removed by the use of an oxide of iron slag, approximately in composition to silica 10 to 15 %, and with the exception of a few per cent. of lime, oxide of manganese, etc., the balance to be oxide of iron in the ferroso-ferric state. It will be necessary:

1st. To supply sufficient slag bearing oxide of iron to complete the oxidation of the metalloids, and to give a base to combine with the phosphoric acid formed.

2d. To supply a slag that shall not be too liquid at the temperature employed in the rotary furnace, and yet not too pasty at that temperature.

3d. To have the percentage of silica so low on the one hand that the slag may be basic in respect to phosphorus, and yet on the other hand sufficiently acid to have the oxidation of the phosphorus effected comparatively slowly, and also to avoid the presence of very basic slag in the resulting ball, which would in the latter case almost surely yield a product that was hot-

short. A slag sufficiently acid, containing say 15% silica, is a good one, and also for the further working of the iron in the reheating furnace. For the reason given above, a lining of bauxite or magnesite (both being very infusible) will be preferable to oxide of iron, the latter making the cinder too basic. The lining may be made in one piece by ramming into place calcined and crushed bauxite or magnesite, mixed with a sufficient amount of a neutral iron slag, so that upon the application of a high heat the lining will glaze over the surface and the semi-fusion of the outer coat will assist in keeping the lining in its place. Or the lining of the furnace may be effected by using magnesite or bauxite bricks, but on account of the expense of magnesite brick doubtless bauxite will be preferred. As to the amount of slag necessary for the work required, if we have 100 lbs. of desiliconized melted metal needing treatment containing, say, silicon 0.05%, carbon $\frac{1}{2}$ %, phosphorus $\frac{1}{2}$ %, and sulphur 0.05%, there would be required (neglecting the silicon and sulphur) approximately 6.58 lbs. magnetic oxide of iron ($\text{Fe. } 30\frac{1}{2}$) for the reactions which theoretically would give 3.41 lbs. of metallic iron and 3.01 lbs. of ferric phosphate, which would mean a "cinder" composed entirely of iron phosphate, and which would, of course, want dissolving in other iron bearing slag carrying excess of oxide of iron, to give the required bulk for protecting the iron from oxidation in the further working of the heat in the rotary furnace, and to dilute the phosphate of iron for after considerations. Twenty-five per cent. of the weight of the pig iron of cinder will probably be wanted from the following calculation :

If we suppose that the composition of the cinder used was,

Silica	15 %
Protoxide of iron	36 "
Lime, oxide of manganese, etc	5 "
Proto-sesquioxide of iron	44 "
	<hr/>
	100 %

and 25 lbs. is used per 100 lbs. of metal treated, then we should have:

Silica.....	3.75 lbs.
Protoxide of iron.....	9.00 "
Lime, etc.....	1.25 "

Proto-sesquioxide of iron, 11.00 lbs., less 6.58 lbs. used, equal to 4.42 lbs., and added to cinder 1.14 lbs. of phosphoric acid and its quota of magnetic oxide of iron, 1.87 lbs., composing the slag. The composition would then be approximately

Silica.....	17.50	
Ferrous oxide.....	42.00	- Iron, 32.66
Lime, etc.....	5.60	
"Free" magnetic oxide		
of iron.....	20.60	} " 21.44 <u> </u> 54.10 total iron.
{ Phosphoric acid.....	5.30	
{ Mag. oxide iron.....	9.00	
	<u>100.00</u>	

Here the per cent. of silica finally obtained is not too high, and the per cent. of phosphoric acid is not too high to be unsafe. If a cinder containing a large amount of phosphoric acid be mixed and carried away with the balls of iron from the rotary furnace, there is danger of a partial reduction of the phosphoric acid when the muck bars are highly heated in the finishing process. It may be, however, that 25 % of weight of pig of cinder will be insufficient to give the bulk required for the purposes before mentioned. In such case more must be used.

In the above calculations as to cinder composition nothing is allowed for the wear of the bauxite or magnesite lining, which would make a slight difference in the composition of the slag.

THE COMPOSITION OF THE SLAG AFTER REFINING.

From the calculation given it will be seen that the slag can be used again, by adding sufficient oxide of iron, Fe. 304,

or roll scale to restore the necessary per cent. of Fe. 304 for the oxidation of a fresh charge. It is well known that 15 % of silica gives a fluid cinder, and even more silica, say to 19 %, is sufficiently basic to remove phosphorus in a basic process. Of course the cinder will have to be modified according to the per cent. of phosphorus present in the pig iron. To render the cinder whose composition has been above calculated available for further use, and for the treatment of a similar pig iron, the addition of 20 % of Fe. 304 to the said cinder would give a mixture whose composition in per cent. would be

Silica	14.56
Protoxide iron	34.93
Lime, etc.	4.85
Proto-sesquioxide Fe.....	41.25
Phosphoric Acid.....	4.40
	<hr/>
	99.99

It is questionable from this whether this cinder is sufficiently pure to use again with only a 20 % addition of Fe_3O_4 .

If metal can be delivered to balling furnaces with a practically definite composition, and the slag mixtures are regulated by weight and analysis, we surely can expect to get more uniform results than by the old methods used for this character of material. I am aware that methods may look well from a theoretical standpoint and prove to be utterly worthless in practice, but I cannot but think that the method outlined is feasible.

One of the chief advantages to be derived from producing iron in large masses is the greater economy obtained in fuel, repairs, labor, etc. For this reason, with a process as outlined able to handle large weights of material in one charge, we could, by giving similar treatment to this material as that given to ingot metal, obtain billets and slabs in lieu of muck bars, and on this account obtain solider and cleaner iron for all purposes. If large appliances are used to treat such material

in large masses, the reduction in area to a billet will be sufficient to make it unnecessary, in many cases, to resort to shearing and piling. The experience of iron manufacturers goes to show that from a ball produced in a puddling furnace and weighing say 150 lbs., there is insufficient work upon it to produce a satisfactory billet from the puddled ball, when treated in an ordinary squeezer and muck rolls. The billet so made is too rich in slag and oxide of iron to produce a finished rod or small round. For this reason the practice is to roll into flat bars, cut up and reroll into finished iron. Some years ago, it will be remembered, that the large balls made in the Danks rotary puddling furnaces, and whose weight was, I think, about 1,000 lbs., were squeezed in a large horizontal squeezer and then wash-heated and rolled into a wide and long muck bar. Similarly, it seems to me, if the weight of the charge treated, as outlined above, is from 1,000 lbs. to 1,500 lbs., and a ball approximately this weight be produced, and by a special treatment such as could be had in a hydraulic squeezer, and still further treated by wash-heating and then rolling in a sufficiently large blooming mill to a billet 4 or 5 inches square, that the billet would be found sound and free from patches of basic cinder, on account of the large amount of work given and from the "controlled" quality of cinder carried from the furnace by the ball. Even if this were not realized, still the product could be rolled into wide and long flat bars, and there would still be the advantage of handling much material in a short time, and so increasing the product, which means less consumption of fuel, etc.

DISCUSSION.

DR. JOHNSON—The problem of manufacturing good wrought iron to compete with steel is a difficult one. Did I understand the author to say that a bauxite lining was in actual use or had been tried experimentally?

MR. PETERS—It was merely a suggestion. It has not been tried.

MR. McKENNA—What is the cost of bauxite suitable for linings?

MR. PETERS—About eight or nine dollars per ton.

MR. CAMP—I fully appreciate the importance of the use of wrought iron for some special purposes; but the most serious objection to the proposed scheme is one of cost. Two entire and complete plants would be necessary. The bessemer plant with its enormous first cost, to bessemerize the pig, and in which the continuance of the blow for one or two minutes more, with the addition of the necessary amount of ferromanganese, would give a steel of almost equal value—depending on the market—with that of muck iron, and the vast outlay for puddling furnaces, mechanical or hand, to take care of the enormous output of the conversers—which in this day of fierce competition must be run to full capacity to reduce fixed charges to the minimum, and it is doubtful if the margin between the prices of soft steel and muck or wrought iron, would pay interest charges on this enormous investment. Certainly not under normal conditions of the iron or steel market.

MR. PETERS—I appreciate that it must seem like a step backwards to talk of making wrought iron in place of steel, but nevertheless there is a demand for good iron for which a good price will be paid, and it is to meet this demand that the foregoing suggestions are made. I believe in steel thoroughly, yet there are many places where the use of wrought iron is preferred, such as for screw threads, and where good welding is necessary.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA,

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The one hundredth and ninety-sixth regular monthly meeting of the Engineer's Society of Western Pennsylvania was held in the Lecture Room of the Society's House, 410 Penn Ave., Pittsburg, Pa., Tuesday evening, June 20, 1899, fifty members and visitors being present. The meeting was called to order at 8:30 o'clock by the president, Mr. Harry J. Lewis.

The minutes of the previous meeting were read and approved.

For the Board of Directors, the following applicants were reported as passed and to be voted for at the next regular meeting :

HENRY D. BAYNE, - Manager,
H. W. Johns Co., Pittsburg, Office, Dallas
Ave., Pittsburg, Pa.

LEVEN J. GRAY, - Manager,
Pittsburg Office of Miller, Wagoner, Filsær
& Co., of Columbus, Ohio, 505 Hamilton
Building, Pittsburg, Pa.

CHAS. H. RICH, - Chemist,
Aliquippa Steel Co., Aliquippa, Beaver Co.,
Pa.

The following gentlemen were balloted for and duly elected to membership :

SEWARD BABBITT, - Salesman,
for Wm. Tod and Wm. B. Pollock & Co., of
Youngstown, Ohio, 1217 Park Building,
Pittsburg, Pa.

DAVID F. CRAWFORD, Assistant Superintendent of Motive Power,
Penn'a Lines West of Pittsburg. Care
Penn'a Co., Ft. Wayne, Ind.

GEORGE A. GILFILLAN, General Engineer,
341 Fourth Ave., Pittsburg, Pa.

DAVID S. KENNEDY, Superintendent Rolling Mills,
Homestead Steel Works, Munhall, Pa.

FRANCIS H. KNOX, - Electrical Engineer,
Charleston City Railway, Charleston, S. C.

JOSEPH M. NESBIT, - Attorney at Law and Solicitor of Patents, 705
Park Building, Pittsburg, Pa.

For the Reception Committee, Mr. Wm. Bradford reported, and a collection was taken up to pay some overlooked bills from Smoker last fall.

MR. DAVIDSON read the following report :—

REPORT OF THE COMMITTEE ON THE DEATH OF CAPT. A. E. HUNT.

PITTSBURG, June 20, 1899.

In the death of our late fellow and past President, Captain Alfred E. Hunt, in the vigor and prime of his life, our society is called upon to mourn the loss of one of its ablest and most efficient members, one who for many consecutive years as a director and with committees labored earnestly for the development and advancement of the organization.

Captain Hunt was born in East Douglas, Mass., March 30, 1855, his parents being Leander Batchelor and Mary E. Hunt, the latter of whom survives her son. On the paternal side he counted eight generations of American citizenship and among his ancestors were several who achieved distinction in the New England states. After graduating at the Roxbury high school he was a student of the Massachusetts Institute of Technology, from which he graduated in 1876 at the age of twenty-one, receiving the degree of Bachelor of Science from the department of Metallurgy and Mining Engineering. Soon after leaving the Institute he became connected with the U. S. Geographical Surveys in the West.

Later he became connected with the Bay State Iron Works in South Boston, and from 1877 to 1881 he was manager and chemist at the Nashua, N. H. open hearth steel works.

Captain Hunt came to Pittsburg in 1881 as superintendent and chemist with Park Brothers & Co., Limited, but in 1883 resigned this position, joining with George H. Clapp in the firm of Hunt & Clapp in the establishment of the Pittsburg Testing Laboratory. So successfully managed was the busi-

ness of the firm that in 1893 it merged into the Pittsburgh Testing Laboratory Company, Limited.

In 1888 Captain Hunt organized the Pittsburgh Reduction Company, to manufacture aluminum according to the process discovered by Charles M. Hall. Before this time this metal had sold at \$15.00 per pound, but as produced by the new firm it was so reduced in price that it now sells for thirty to forty cents a pound, permitting of the use of aluminum in a vastly extended field of usefulness. It has been well said that the name of Alfred E. Hunt will for all time be associated with the introduction of this useful metal, once considered almost a curiosity and of limited utility, into the every day world of art. He lived to hear the claim put forth that there would come an aluminum to supplant the iron age, and it cannot be disputed that the world at large owes much to the perseverance, energy and push of Captain Hunt in cheapening the cost of this metal.

Notwithstanding his assiduous attention to business affairs, Captain Hunt found time to take an active part in several of the most important of our technical and scientific organizations. He was a member of the American Institute of Mining Engineers, a fellow of the American Association for the Advancement of Science, and a member of the American Society of Civil Engineers. The Norman gold medal was awarded him by the last named Society for the best paper on engineering at the Chicago meeting of 1893. He was a member also of the American Society of Mechanical Engineers, the American Chemical Society, the Iron and Steel Institute of Great Britain, and the Institution of Civil Engineers of Great Britain.

As Commander of Battery B in the National Guard of Pennsylvania, he was called upon to serve the country in the late war with Spain. He headed the only Pittsburgh command called to enter hostile territory, and was with his Company with General Miles in Porto Rico, from which island he returned in August last, broken in health. The hopes that were en-

tertained that, with his robust constitution and physique, his return to a cool climate among friends and kindred would restore him to health, were doomed to disappointment. It seemed as though the very energy he put forth to recover resulted in his further exhaustion. He returned to Pittsburg every man of his command safe and sound, and a number of them owe their lives to their Captain's watchfulness of their diet and the exceeding care he took to supply them with filtered water which he procured for them from appliances purchased with his own means.

While prompt and decisive in his actions, Captain Hunt was open and courteous in his manners, while kindness, frankness, and humor mingled in his address. To many of the younger members of our Society and especially young engineers entering Pittsburg as strangers, he lent a helping hand by assisting them in finding employment and ever was his heart in the right place.

His record as a member of our Society dates from October, 1881. As a director he served from January, 1887, to January, 1889, and as President during the year of 1892. He was ever ready in debate and noted for his clearness of diction, accuracy of statement, conciseness and logical conclusions, and we will miss the cheery tones of his voice; but so long as the Engineers' Society of Western Pennsylvania maintains its organization its members will be proud to point to the pages in its history adorned with the name of Alfred E. Hunt.

Your committee propose for adoption the following:

Resolved, That in the death of our late esteemed member, Alfred E. Hunt, past President of the Society, the Engineers' Society of Western Pennsylvania is called upon to mourn the loss of one of its most distinguished members. His record was an honorable one and his memory deserves to be cherished.

We beg to extend to the family of the deceased our heartfelt sympathy in their great bereavement.

Further it is Resolved, That the Secretary forward to the family of the deceased a copy of the report of the Committee and a minute of these proceedings.

GEO. S. DAVISON, Chairman.

GEO. H. CLAPP,

CHAS. E. DAVIS,

THOS. P. ROBERTS.

It was moved and seconded that the resolutions be entered upon the minutes and a copy sent to Capt. Hunt's family. Motion carried.

For the Smoke Committee Prof. Fessenden reported as follows :

REPORT OF COMMITTEE ON SMOKE PREVENTION.

Your committee was requested by Mr. E. M. Bigelow, in a letter dated March 1st, 1899, to furnish him with a rule for the rating of boilers, as this question was one of some importance in connection with the suppression of smoke in Pittsburg.

Your committee has therefore collected all the data it could, and has been in correspondence with the principal manufacturers of boilers and stokers. It has also sought the advice of engineers who have had experience in the matter. We would respectfully report as follows:

In the rating of steam producing plants the following things are to be taken into consideration.

1. Amount of heating surface per H. P.
2. Amount of grate surface per H. P.
3. Amount of draught.

As regards the first of these your committee does not feel able, on the evidence furnished, to fix any settled amount of heating surface per H. P. For, whilst it is undoubtedly true that in the majority of cases the following rates will be found to be proper, i. e.,

Horizontal Tubular, 12 sq. feet,

Water Tube, 10 sq. feet,

the boilers being in each case capable of being forced economically to between 50 and 60 per cent. above the rated capacity, yet in at least one case your committee has good evidence that water tube boilers, of one particular type, have been run continuously and economically for long periods with but $8\frac{1}{2}$ sq. feet per H. P. (By H. P. is meant Centennial rating, i. e., either $34\frac{1}{2}$ lbs. of water from and at 212 F., or 30 lbs. of water from 100 F. to steam at 70 lbs. above atmospheric air.

There is another reason why your committee does not consider it advisable to go into this matter, in addition to its difficulty, and that is that by making any hard and fast rule a hindrance might be placed on possible improvements and progress, and manufacturers who might succeed in making the heating surface more efficient might be placed at a disadvantage.

Moreover, for the purpose required such a rule is unnecessary, for, the smoke is produced in the furnace, and it is evident that if we accomplish perfect combustion in the furnace it is a matter of indifference, so far as smoke is concerned, what becomes of the heat, whether it is utilized in a boiler of eighty per cent. efficiency or in one of only ten. It is a matter which concerns only the owner of the plant, who has the right to run the plant as inefficiently as he chooses, and who, if he desires to obtain a knowledge of the best arrangement for efficiency in his case, can always obtain the services of an engineer experienced in such matters. It is therefore not a matter which concerns the general public at all, as it is not when a boiler is working inefficiently, but when it is producing smoke, that it becomes a public nuisance.

As regards the second of these matters, i. e., the area of grate surface per H. P. your committee finds that with the draught mentioned in the following section, the following rates of combustion are to be recommended:

1. Run of mine $\frac{1}{8}$ to $\frac{1}{4}$ sq. feet per H. P.

2. Slack, bituminous or anthracite, $\frac{1}{4}$ to $\frac{1}{2}$ sq. feet per H. P. The air space in grate being taken as 50%.

The above rates are for hand firing. For mechanical stoking your committee finds that the rates should be the same.

As regards the third matter, i. e., draught, we find that the draught should in all cases be measured, not in the stack or in the ash-pit, but in the furnace, over the fire and with the furnace door closed and the ash-pit door open when working the grate at the above mentioned rate.

Measured at this place the draught, in the most unfavorable conditions, i. e., in bad weather, should be :

1. For run of mine, a minimum of $\frac{3}{8}$ inch.
2. For slack, a minimum of $\frac{1}{2}$ inch,

This also should be the same for hand firing and for mechanical stokers.

As regards the method of preventing smoke, your committee has reached the following conclusions:

1. That whilst in an ordinary furnace smoke may be made very light by very careful hand firing, yet in practice this cannot be obtained continuously, and that the use of special furnaces or appliances should be insisted on and made compulsory by law.

2. That the best method of preventing smoke is to burn the fuel in a separate chamber, so that the combustion is complete before the gases touch the surface of the boiler. If the gases are imperfectly burned, then, on coming into contact with the cooler water surface they deposit soot, and smoke is produced. If the combustion is perfect this does not occur.

3. Where this method is not practical, as in boilers already set and where there is no room, the best results are obtained by mixing the smoke, as it passes from the furnace, with heated air, the effect of which plan increases as the temperature of the air increases, thus burning the smoke.

4. That as, even with special furnaces of the above types, with hand firing, the combustion is irregular and hence

some smoke must be produced at times, the use of mechanical stokers is strongly recommended, especially in all plants above 100 H. P.

5. As mentioned above, there is a lower limit of grate area per H. P., below which the furnace is not heated enough to insure complete combustion and smoke is thus produced. For this reason all plants should be subdivided into two units at least, in order that the boilers may never run at a lower activity than one-third of their rated H. P.

Moved that the report of the committee be received with thanks and printed for distribution to the members. Motion carried.

It was moved and seconded that the reception committee lay out plans for an excursion for the afternoon and evening, and ask for responses from the members.

MR. BRADFORD—What date shall we set?

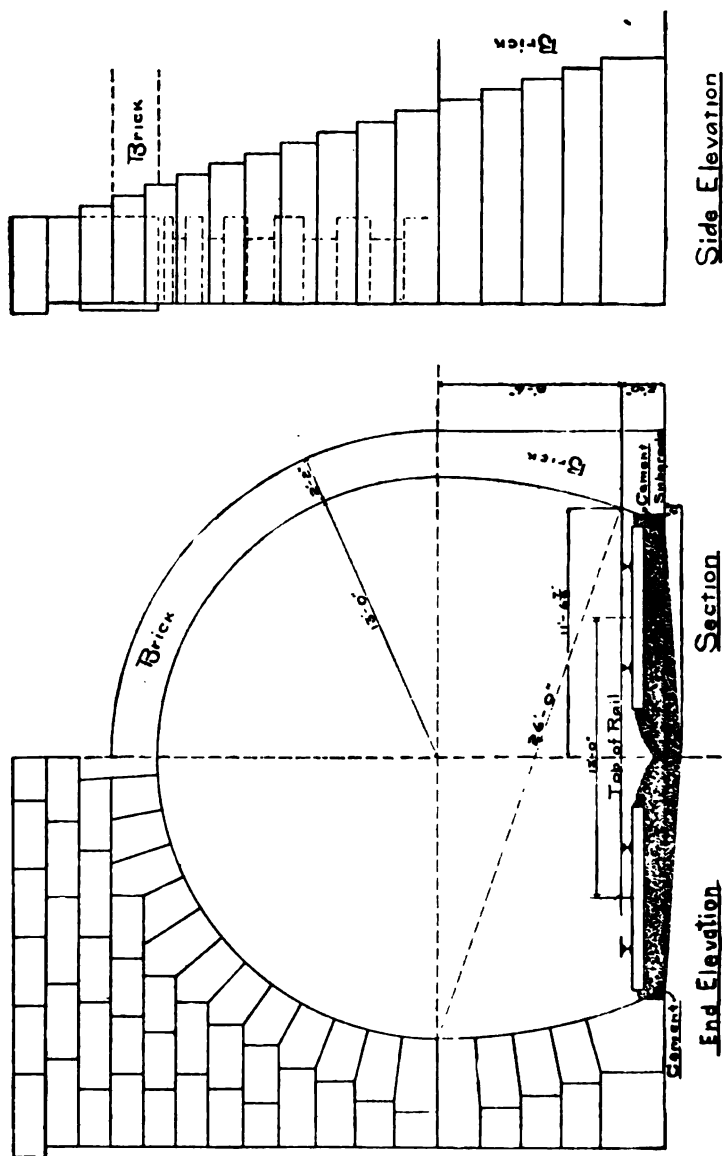
PRESIDENT—Any Saturday in your discretion. (Motion carried.)

The next in order was the reading of the paper of the evening on the "Methods of Construction Used in Pittsburg, Bessemer & Lake Erie Tunnel," by F. E. House, General Superintendent P., B. & L. E. R. R. Co., Pittsburg, Pa.

NORTH BESSEMER TUNNEL.

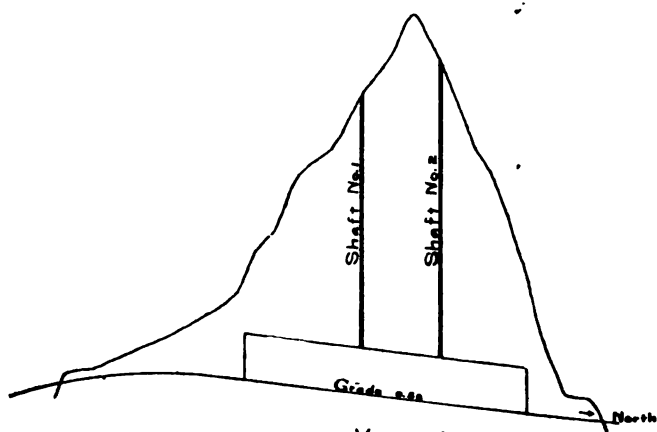
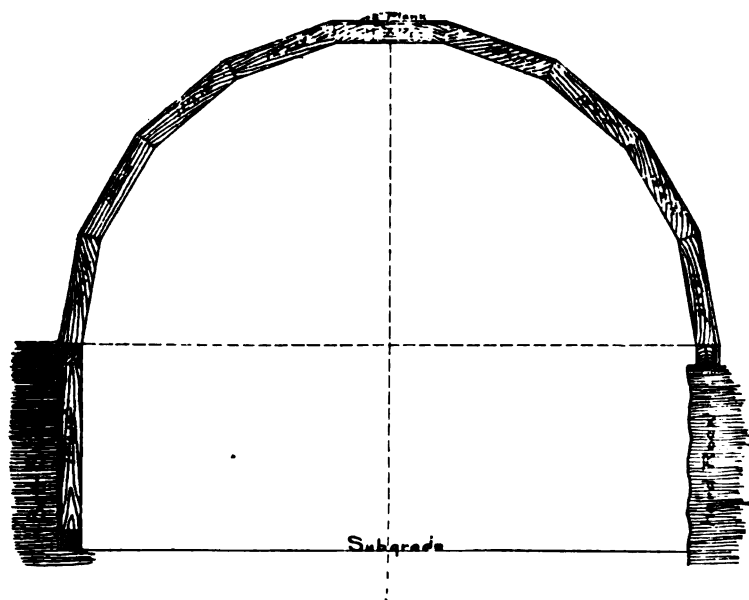
BY F. E. HOUSE,
Gen'l Supt. P., B. & L. E. R. R.

The location of the Pittsburg, Bessemer and Lake Erie R. R., between the crossing of the same of the Allegheny River and the yards of the Union R. R., in the vicinity of the works of the Carnegie Steel Co., Limited, at Bessemer, Pa., crosses the high elevation of the ridge between the Allegheny and Monongahela Rivers, at a point about four miles southwardly from Verona. The elevation of the normal water level in the Allegheny River on the above line is about 723 Government



datum and the elevation of the Union R. R. yards at Bessemer is about the same, while between them rises a summit to the elevation of 1,221 feet, or a difference of 498 feet. The construction of the P., B. & L. E. R. R. with a maximum grade south bound, of $\frac{1}{8}$ per 100 feet, or 31 feet per mile, together with the height decided upon for the Allegheny River bridge, necessitated a tunnel through the summit of the ridge traversed. A double track tunnel was decided upon with the following cross section in the clear, viz: A semi-circular arch with spring line $8\frac{1}{2}$ feet above top of rail, radius of arch 13 feet. From spring line to sub-grade, the circular face was continued with a radius of 26 feet, to an intersection with the sub-grade line, which line is 2 feet below top of rail at the intersection with the side lines. This sub-grade line descends from the side lines to the center line of the tunnel cross section at which line it is 9 inches lower than at the side lines for the purpose of forming a center ditch or drain for water. The length of the tunnel is 2,900 feet between portals, requiring an approach cut, at the north end, with a depth of 57 feet at the tunnel portal, and at the south end with a depth of 45 feet at the portal. The grade in tunnel ascending southward, is 0.581 per 100 feet for the entire length of the tunnel proper, the summit of the grade between the rivers being, in the south approach cut, 900 feet distant from the south portal. The greatest depth from the hill summit to sub-grade in the tunnel is 221 feet at a point 1,200 feet from north portal.

It was the expectation of the Railroad Co., judging from soundings and from the exposed rock near the south portal, that the character of the material through which the tunnel was to be driven was such that *temporary* timber supports *only* would be required during the progress of the excavation, and that such supports could safely be removed in advance of the erection of the permanent masonry lining; but the opposite was found to be the case, as will be shown later in our narrative. One very important consideration in the construction of this



Scale: Ver. 1" = 50'
Hor. 1" = 1000'

work, was the limited time allowed for its completion sufficiently to allow the passage of trains through it. It was to be finished in the fall of 1897, and the first work done upon it, in any way, was the beginning of the excavation of the north approach cut, which was commenced November 30, 1896. Similar work began on the south approach cut December 29, 1896, and in the latter cut there was to be removed a yardage of 58,900, the larger portion of which was hard shale, all requiring blasting, mingled with strata of hard sand stone, the latter of which developed, at the portal, into a solid ledge about 8 feet in thickness, dipping slightly from the horizontal as the excavation proceeded northwardly.

In the north approach cut were 25,600 cubic yards of excavation, largely clay, underlaid with soft shale, which, upon exposure to the weather became soft. This latter characteristic occasioned considerable difficulty in its support, not only in the sides of the approach cut, but also during the first 200 feet of the tunnel excavation. After this it hardened. As the winter of 1896-97 was notoriously wet and soft, the removal of sufficient material from the approach cuts to permit access to the work on headings was rather of a formidable proposition under the consideration of bad weather and short time. This condition was not improved by the fact of being obliged to transport the larger portion of the excavated materials from the south approach cut, a distance of nearly two miles, to a large embankment. The element of time also made necessary at least one shaft through which two headings could be run, and this shaft was located at a point 1,250 feet from the south portal, and the excavation of the shaft was begun December 19, 1896. Ultimately as the work progressed, with its usual heartbreaking delays and unlooked for emergencies, a second shaft was found necessary, and it was located 850 feet from the north portal. These shafts were 10 by 20 feet in the clear of excavation and were lagged and timbered from the top to the crest of the tunnel heading. Shaft No. 2 was begun February

17, 1897. Shaft No. 1 was 129 feet in depth to top of tunnel heading and Shaft No. 2 was 134 feet deep.

These shafts were located at such distances from each other as to insure, as nearly as possible, the headings from the portals meeting the headings from the shafts at about the same time that the headings between the shafts should meet. The headings between shaft No. 1 and the south portal met July 29, 1897, and those between the shafts met July 25, 1897, while those between shaft No. 2 and the north heading met July 17, 1897; all of which was rather close and altogether satisfactory as far as the selection of the shaft locations was concerned. The headings in shaft No. 1 were begun February 17, 1897, and in shaft No. 2 on April 22, 1897. The heading at the north portal was begun March 1, 1897, and at the south portal February 19, 1897.

The average distance per working day, exclusive of Sundays, that headings were driven was about 4 feet; the headings from the portals making some better progress than those from the shafts. Compressed air drills were used, the contractors having 24 altogether upon the work. These were the Ingersoll-Sergeant drills, F 24 auxiliary valve, 3½ inch cylinders. Their stroke can be made variable and their work was satisfactory. The compressed air generating plant consisted of 2 Ingersoll-Sergeant class A pattern compressors with steam cylinders 20x24, and air cylinders 20½x24, each with a capacity of 809 cubic feet of free air per minute to a pressure of 100 lbs. per square inch. The compressing plant was located at a point about 1,200 feet north of the north portal and the air was conveyed in 8 inch main pipe and distributed for use at the different points. The general size of headings was about 8 feet, center height, by 19 to 21 feet in bottom width, excavated, of course as nearly semi-circular as possible. The timbering required to support the roof and sides of headings was furnished in the shape of round timbers in the rough, which were obtained in the vicinity of the work.

The first bench, following the headings, was loaded over chutes into ordinary grading side dump cars, in the portal headings, and hauled away by small locomotives. In the shaft headings, mining cars were used and the larger part of the material removed through the shafts was lowered down over inclined tracks to the portal cuts and there dumped into the side dumps and moved thence to the points of deposit.

The lower bench in tunnel was blasted loose and loaded into grading cars by the use of steam shovels, the booms of which were shortened to admit of their entrance into the tunnel and their operation was very successful and satisfactory. It will be readily seen that the use of compressed air in the steam shovels, made their use practicable on account of good ventilation and the absence of smoke. This lower bench, which averaged about 8 feet high, and practically the entire width of the tunnel excavation, was taken out in 101 working days, or an average of 29 lineal feet per day. I will say here that the track was laid through the tunnel September 25, 1897, or in less than 10 months from the time the first excavation was begun in the approach cuts. As previously stated, it was expected that the timbering required to support the roof and sides of the tunnel excavation, until the introduction of the permanent masonry lining, would be but temporary and could be removed, but as the work progressed it was found that the material was so soft and treacherous that close and heavy timbering was required and *not* removed. This plan was therefore followed, not only to insure safety to the men on account of avoiding caves and falls, but also because it would allow the use of the tunnel by regular trains before the masonry lining should be in place. These timber setts usually consisted of 10x10 and 12x12 squared posts with a wall plate above at the spring line, and in some places a mud sill below. On the wall plates was set the tunnel center timbering consisting of 9 segments. There were used 623 setts of these timbers, set generally 5 feet centers, excepting in occasional soft places, where they were placed closer.

Plank lagging back of and overhead of these setts as required. The original plan called for stone, range masonry lining for the walls from sub-grade up to the spring line of the arch, but inasmuch as the R. R. Co. desired the use of the tunnel as soon as possible, an arrangement was made with the contractors to use a special sized tunnel brick 3x4x9 inches in the stead of stone and make the arch of ordinary sized hard burned brick. The cross section of the bench walls was changed so as to make the back nearly plumb and thus the thickness was materially increased, at the bottom, over what was contemplated in the stone work. The arch consisted of 6 courses of brick. The brick work in the bench walls was started to be laid radially to the circular face of the wall but the difficulty of keeping the brick from sliding on their beds while being laid, particularly near the base of the walls, where their inclination from the horizontal was the greatest, caused us to allow all brick in the side walls to be laid horizontally, drawing in the face brick in each course to conform to the circle on the face. A thick body of cement was laid along the track side of the walls at the bottom and sloped toward the center of tunnel to prevent water getting under the side walls. The mortar used in the brick work was composed of 2 parts sand and 1 part of Improved Union Cement.

Occasional "weep-holes" were put into the side walls near the bottom and consisted of clay tiling running through the wall to the backing or filling.

Our specifications called for the arch to be covered with roofing felt or heaviest tarred paper and that, in turn, covered with a cement plaster at least 2 inches thick, all down as low as the spring line, and this was carried out as perfectly as possible, but the difficulty of placing this plaster a sufficient distance ahead of the packing to insure its hardening before the stone packing is placed upon it, makes its use of doubtful utility. The spaces between the back of the arch and walls and the sides of the adjacent excavation, were thoroughly

packed with stone, broken to pass through a 3 in. ring and tamped into place with hammers. There were used 5,792 cubic yards of this packing, and the most of it was quarried from adjacent cuts. The presence of the timbers back of the masonry lining made great care necessary in the placing of this packing. The work of placing the lining was begun in the north end, August 12, 1897, and in the south end, October 6, 1897, and was completed, February, 1898.

This portion of the work was conducted at a number of points at the same time, the arrangement being that the contractors had the exclusive use of the tunnel at night, the R. R. Co. using it during day time to the exclusion of the contractors' work trains, the contractors, however, doing brick work during the day, not interfering with the passage of the trains of the R. R. Co. The facades were built of substantial range masonry, and thus far no portion of the work shows any sign of weakness.

DISCUSSION.

MR. WILKINS—Were the steam shovels propelled by compressed air?

MR. HOUSE—Yes; the question was whether there would be air enough to run two shovels, but there was plenty.

MR. WILKINS—What was the pressure of the air?

MR. HOUSE—I cannot tell you exactly.

MEMBER—Am I to understand that the air capacity is 809 pounds?

MR. HOUSE—Yes, that is it.

MR. BRADFORD—I would like to ask what the cost of that tunnel was per foot.

MR. HOUSE—That is one question which I must ask to be excused from answering. The south shaft was left open during the progress of this work. We have left the south shaft open permanently as a ventilating shaft, although I did not at first think it would be necessary.

MEMBER—How much air did the compressed plants deliver?

MR. HOUSE—Their capacity was listed at 809 feet per minute. I don't know how much that was reduced.

MR. JOHNSON—I would like to ask Mr. House if the covering over the arch has shown any signs of seeping or letting water through.

MR. HOUSE—Not much, except at the south end of the tunnel; it seeps there a little.

MR. ROBERTS—I would like to ask if you have much trouble with the water.

MR. HOUSE—None at all. In fact, for a long time after the opening of the tunnel it ran from a surface ditch at the south end, clear through. At present it is very dry.

MR. ASHWORTH—Gentlemen, this is a very interesting and valuable paper, and I think the author deserves a great deal of credit for it.

It was moved and seconded that a vote of thanks be given Mr. House for the paper of the evening. (Motion carried.)

MR. DAVISON—I would like to ask Mr. House if he thinks more time should have been taken in regard to the data and in regard to the consideration of the strata to be encountered; whether in his opinion it could have been conducted in a different way after more information was gained.

MR. HOUSE—I don't think there would have been any difference in the *method* pursued, for we had to finish in that length of time.

MR. DAVISON—Mr. House's answer brings up a point which I think is one that, if there is anything to be criticized in the present work of the engineer, it is the point of the engineer not having proper time in which to prepare his work for the contractors, and therefore, not having proper time to prepare, he cannot investigate and lay out his work properly beforehand. It is his fault only so far as he allows his clients to force him to do work in too short a time. The engineer's

clients, as a rule, will take months and years to consider the feasibility of schemes in which they need the engineer, but after the question is settled the engineer has only a day to prepare for a large undertaking, and therein lies a great deal of the trouble and an unreasonable expenditure of money for the client.

MR. LEWIS—I would say that in my profession the business of an engineer is to make things happen. If a man wants things to happen the day before yesterday, it is his business to make them happen that way. It is all well enough to talk about ideal conditions, but when we come up against the actual conditions, is when we will find things the same on nearly all occasions.

MR. BOLE—I would like to get a little information on this question. How is a man to know how much it will cost him to drive a tunnel when he doesn't know anything about the conditions and rock to be encountered; how is he to estimate whether he will make a fortune or go to the poor house?

MR. HOUSE—In this case there was a price of so much per yard, that is for the excavation in the tunnel proper, and we allowed a full measurement of six (6) inches larger than the masonry lines would require. We allowed so much per cubic yard for the masonry lining in place, then the *temporary* timbers the contractor put in at his own expense. When we found that the timbers which supported the roof and sides were required to be left in, we made arrangements with him to pay his actual timber bills, plus a percentage for superintendence and use of tools. That is the worst way it could be done; the difficulty in such a case is to keep a very close check on him. The best way to do it is not to do it that way, but to make the price so much per thousand feet for the timber in place, that is, the timber that remains in. The best method of all is to let the tunnel at so much per lineal foot finished. Of course, your client would not know exactly what his tunnel would cost him until it was finished.

MEMBER—Supplementing Mr. Bole's question, I would like to know how a contractor knows how much to charge.

MR. WILKINS—The contractor is supposed to have had some previous experience in work of this character, enough at least to enable him to have a pretty good idea of the cost of tunnel work. Mr. Bole when he is building a new engine can tell pretty closely the probable cost from other engines that he has built. Estimating the cost of tunnel and shaft excavation is, however, not nearly so an exact a science as it is in building steam engines and many a contractor has found this out to his cost. I know of an instance where a contractor took a contract for sinking a coal mine shaft, and it was his first experience in this class of work. He was very fortunate and had almost a dry hole, scarcely any water being encountered in the entire 400 feet. He had a pretty good price for his work and made quite a handsome profit on the contract. Based on this experience he took a contract for sinking a shaft in another part of the state at a price of \$20.00 per foot less than the first. This shaft did not prove to be a dry hole, very large quantities of water being met with, and by the time the bottom was reached the shaft was so full of pumps and pipes that there was hardly room for the workmen. Instead of making a profit as his first experience led him to believe he would, he left quite a large amount of money in the hole. By reason of the uncertainty of work of this class contractors generally add a pretty good percentage to their figures for contingencies.

MR. JOHNSON—In Western Pennsylvania the geological formation is pretty well known by the contractors through the reports of the geological surveys, and we have a pretty fair idea of what kind of rocks will be encountered.

Upon motion the Society adjourned at 10 P. M.

REGINALD A. FESSENDEN,
Secretary.

REPORT OF POWER COMMITTEE.

The undersigned were appointed by the President of your Society as a committee to ascertain, if possible, the cost of power, and to report the results of the investigation. The time of this appointment dates back for nearly two years, and the fact of the existence of this committee may have escaped the memory of most of the membership.

The delay in making a report has been due to the almost total impossibility of obtaining reliable data, and this is no more than your committee anticipated before undertaking the task. To demonstrate that it was not neglect on the part of your committee, that so little data is forthcoming, the following statement of procedure is made :

Your committee met and, after a good deal of discussion, decided to issue to the members of the Society and to a large number of manufacturers and users of power, a list of questions to be answered categorically. These questions were carefully selected, and were intended to bring out answers which would be explicit and definite, and were so framed that they could not well be answered except by positive statements of facts. The list of questions was accompanied by a letter setting forth the purpose and aims of the Society and issued in such a way as to afford opportunity to impart the requisite information without prejudice to the contributor. Out of several hundred such circulars sent to all the prominent users of power in this section of the country, only about half a dozen met with a response, and all of these except one are incomplete and insufficient. A copy of this list of questions is appended to the report. It will be seen that the subject is divided into five general heads, viz.: Data as to boilers where the steam is generated; data as to engines, pumps, etc., where the steam is used; investment; depreciation; and operating expenses.

The majority of these questions relate to steam power, because the amount of power otherwise generated is insignificant in comparison, at least in this community in which the committee had hoped to obtain its data. Your committee considers that the fewness of responses and the lack of definiteness and completeness in the few which did come, is very significant, and should be brought strongly to the attention of the members of this Society. Undoubtedly the reason why so few people are found to contribute such information as is here sought is because the average user of power *does not know*.

If this committee does no more worthy thing than to demonstrate that the cost of power is rarely known even to the man who pays the bills, it will not have existed wholly in vain. Any observer who looks about him in this busy city of Pittsburg, and takes cognizance of the enormous value of fuel which must be daily consumed, will readily conclude that there is here a large and promising field for investigation, and that the lack of definite knowledge in so large a matter is, to say the least, not creditable to those who, for the sake of economy and self interest, ought to know.

The first of the divisions above made, viz: the boilers, may be considered separately. The responses that your committee received were more nearly complete on this score than on any other, and the reason is evident.

As a rule, the number of boiler batteries in a plant are few as compared with the number of engines, pumps and other machines using steam thus generated. In a great many establishments one central boiler plant is sufficient, and the coal burned there is, so to speak, localized, and can be accounted for. In the same plant there may be hundreds of feet of conducting pipes, and dozens of engines, steam hammers, presses and other means of wasting this steam.

Boiler plants in general are easily susceptible to tests not only of the searching and scientific kind, which can be made

only by an expert with numerous assistants at a considerable expense, but also of an every day character and with a good degree of reliability. The chief elements of such an investigation are two only, viz: the water evaporated and the fuel consumed in doing it. These two quantities can usually be obtained accurately by the proper provision of meters for the water and weigh scales for the coal. It is always conducive to economy and good order to have those who are entrusted with the use of any material, realize that an account is expected, and it is also conducive to wastefulness and extravagance to have such people know that no trace is being kept of their doings. The very presence of the meter and the weighing scales is sure to have a good effect. If a daily log is kept, the meter is read and recorded at two or more definite periods each day, and the water thus used is set over against the fuel burned, the most ignorant or careless firemen will be apt to keep a sharper lookout on all the duties entrusted to him, than though he can console himself with the cheerful reflection "the boss don't know." The expert investigation, above referred to, usually establishes a basis of performance with which the daily performance may be daily compared, and when the performance in daily operation falls below the average, an opportunity is afforded to promptly discover the fact and the reason. If this should lead to an investigation, correction and a restoration of standard good performance, it is no more than should be expected.

The reasons for failure to obtain in daily practice the occasional results obtained by expert tests, are generally clear and often valid, but they should not justify carelessness in firing, etc. Such tests are usually made in new plants which have been put in on a guarantee of performance, and which are thus in the best possible condition to do the best work. Such tests are usually made with the most expert firemen, using the best intelligence to obtain a good performance. Boilers are clean, pumps tight, pipe joints dry, stack draft

best obtainable, grate bars entire, no leaks in brick work, feed water is warmed to a maximum; in short, all is as near perfect as can be made. The amount of water and fuel used is carefully measured and a ratio between the two is obtained which may ever afterwards be set up as an ideal. Some of the responses to your committee's questions do give valuable information on this point, notably that of the Solvay Process Co., of Syracuse, N. Y., who report the evaporation of 11.2 lbs. of water per pound of dry Bituminous coal burned. Their daily performance is stated to be about 9.5 lbs. of water evaporated under actual conditions per pound of coal. The boiler pressure in this case is 120 lbs. gauge pressure, and the temperature of feed water is 165 to 175 degrees Fahr. The firemen and all attendants in such a plant might well feel their individual responsibility, and without such a feeling the obtaining of such a record is an impossibility. There is available for those particularly interested, a great amount of information in the maximum performance of good boiler plants, and a general summary of such would probably establish as obtainable in good boiler plants, a ratio of about nine pounds of water per one pound of the best fuel.

The manager who provides a suitable water meter and coal-weighing apparatus and insists on their being properly used, may therefore make his own comparisons between what his plant might do and what it actually does do.

This is the data which your committee believes is in the possession of the very few, and which might be and by good rights ought to be in the possession of every man who owns such a plant. This ratio between water and coal is injuriously affected by a great many factors, some of which have been already suggested, and it will be obviously the duty of the chief engineer or chief foreman to locate the reason why his performance is not equal to the average of previous periods. If the boilers are dirty or full of scale, *clean them*, if the brick work leaks air, *stop the cracks*. If the fireman leaves the

furnace door open in order that he may lie on the floor and read "Encyclopædia Britannica," make him stop the practice and use a candle, etc., etc. Use the thermometer on the feed water, inspect the ash heap for unburned coal, keep the grates uniformly covered.

If the performance is poor because the equipment is inadequate, *correct* it. The value of the fuel burned under a boiler, during the lifetime of that boiler, will make the first cost of the boiler look very mean and insignificant, and will demonstrate that it is unwise to "put up with" an unsuitable equipment. In such plants as run day and night for, say 300 days per year, even in Pittsburg, the cheapest fuel depot in the world possibly—the value of fuel burned in a single year may easily exceed the price of the boiler. The following figures appended to show that the statement is correct. Assume that one H. P. boiler capacity is the ability to evaporate 30 pounds feed water per hour. Assume an average ratio of coal to water as being 1–9. Such a boiler will require $\frac{30}{9} = 3\frac{1}{3}$ pounds coal per H. P. per hour, and in one day of 24 hours $24 \times 3\frac{1}{3} = 80$ pounds of best quality coal will be consumed per H. P. In 300 days the amount of coal thus burned reaches the very considerable total of 24,000 pounds, or 12 net tons. The best quality of coal will be required to give such a performance and the coal will cost the average consumer nearly, if not quite, \$1.00 per ton in Pittsburg. The annual cost of fuel then will be \$12.00 per H. P., and this is much more than the first cost of some types of boilers, and is almost equal to the price asked for the very best. The lifetime of a good boiler ought not to be less than 15 or 20 years, and during such a life, our aforesaid boiler may have consumed for each H. P. in capacity, fuel worth from \$180 to \$240, and even more. Such figures do not over-state the case—indeed they are entirely too low as compared with the actual results of ordinarily good plants, and it is not improbable that the results thus indicated may be 50 % too good for

a great deal of practice. If this be so, then a 20-year boiler may have to answer for the disappearance of, say \$360 per each H. P. of its capacity, or for a 100 H. P. boiler, the enormous sum of \$36,000 "gone up in smoke." Of course such a boiler is "laid up" for part of its time, and may not be fired to capacity for 300 days per year, but in such case it is earning less, and the validity of the argument is not affected. Is such a sum worthy scrutiny, and is the subject fairly comprehended by those whose duty it is to take care of such matters?

Having thus called attention to some of the salient features of the boilers, and their part in this matter of power economics, it may be proper to look now to what becomes of the steam which has been generated at so considerable cost. Perhaps the first thing to be mentioned is the loss in pipe lines, and this loss is often very great. It will depend on the size and length of the steam lines.

It will depend on their protection or exposure to the elements, and on their protection from radiation. This line loss will be reduced if all pipes are under roof, and if they are protected by non-conducting materials.

After the pipe line it may be proper to mention the usual accessory—the boiler feed pump or pumps. These are generally very effective instruments in preventing the blowing off of the safety valve, and because of the rather unfortunate fact that they will run well even when in the worst condition for economy. They are often overlooked when search is being made to determine "where the steam is going to." All such pumps may be classified as bad, but some are worse, particularly those whose water plungers cannot be seen, and whose water leakage is wholly an unknown quantity. For the usual case it will be fair to assume that about 5% of the steam made in a boiler will be required to actuate the average direct acting feed pump which supplies water to that boiler.

If such apparatus as steam hammers, steam accumulators,

etc., are employed, the difficulty of tracing out the consumption of steam will be greatly increased.

The main consumer of steam ought to be the engines, as it is on their account chiefly that the boilers are called into existence. As of engines as of pumps and other things, it may be said some are good, some are better and some worse.

To properly test an engine furnishing motive power in a manufacturing establishment is not as easily done as to test the boiler which makes the steam, particularly when (as is usual) other machines beside the engine in question draws steam from that boiler. There is no readily procurable "meter" for measuring the steam as it enters the engine's supply pipe. Even if such a thing were possible to devise, the *amount of power* furnished by such an engine is subject to a wide variation from one minute to another. This is more aggravated in some cases than in others. To take an extreme case, suppose the engine under discussion to be employed in rolling mill work—a very common use hereabout. For a moment or two the engine may be struggling to its utmost capacity to put a "bloom" through the rolls, and the next instant, relieved of all work, it has only its own friction to overcome. Such periods are not at all regular in their recurrence nor in their duration, and it is impossible to do much more, even by the use of the indicator, than to obtain the maximum and the minimum and then "guess at" the average H. P. developed. In a less degree this is true of practically every engine and motor of every kind.

The widely discrepant reports which are sometimes made regarding the *cost of power* originate in this difficulty of determining the amount of power developed. It is not an uncommon mistake to assume that this *amount* of power corresponds to the capacity of the engine or to its *nominal* size. Thus the user of an engine whose maker rates it at 100 H. P. will be likely to divide his coal bill by 100 to determine the cost per H. P., and in doing so may deceive himself badly.

Such a one may conclude that he develops 100 H. P. at a cost of say \$20.00 per H. P., when the fact is that he is developing an average of only 50 H. P. at an average cost of \$40.00 per H. P. per annum.

Your committee believes that this fact was forcibly brought out by the expert tests of steam plants in Buffalo, said tests being made at the instance of the Niagara Falls Power Company, which was seeking to supplant isolated steam plants by the use of electric power obtained at Niagara.

The difficulty of obtaining absolutely correct data as to average H. P. required for a given industry should not, however, be in the attempt to obtain such data. The steam engine indicator ought to be used a great deal more than it is, not only for determining the power which is being developed, but because it will reveal also the proper or improper performance of all the various functions within its ken, and thus bring about corrections of errors which otherwise would run on indefinitely.

It is not at all unlikely that many an engine has lived its day honored and respected as being a member of "good family" and, per consequence, economically, when inwardly it may have been a "raving wolf," all because the vast majority of engines by number never see an indicator after they leave the builder's establishment. This is the more probable if the engine be a large engine on a small load.

There is scarcely a single feature of design that excels in importance the matter of *correct size* of an engine to do a given duty economically, and the idea of having an engine "plenty big enough," while well enough in its way, is easily capable of being overdone. Of course, the converse is also true and *too small* is no better than *too big*, except that errors in this direction are usually detected and corrected more promptly.

It is not your committee's intention or desire to continue this subject to the bitter end. As before stated, the literature on steam engineering contains a vast amount of data obtained

in a great many special tests of engines, boilers, and other accessories of power generation. No attempt is here made to introduce statistics of such tests. The main object of your committee is to report that it has been unable to obtain actual data from the actual users of power, as to the actual cost of such power, and to emphasize the opinions of the committee that reason for such failure to obtain is that the users of power do not know what they are paying per H. P. per year or any other time. We would impress this point strongly upon you as a body of specialists, whose interests are affected directly and whose efforts may be directed towards a betterment of present conditions.

The consideration of investment, depreciation, and operative expenses is even more wholly ignored in the responses to our application than the data affecting fuels. We account for this in the fact that there is a more or less secretiveness about such matters, and because the proper distribution of such costs is in itself a difficult matter. The cost of fuel per H. P. has been the objective point of your committee. The total cost of power per H. P. is so largely a matter of book-keeping, and this in turn so largely a matter of opinion on the part of the book-keeper, as to make comparisons difficult.

In a general way, when the cost of a H. P. per annum can be expressed in pounds of coal; each interested person can do the rest for himself.

We will now consider specially the responses received from the Allegheny City Municipal Electric Light Plant, which contain much valuable information. The list of questions appended is filled out with the responses received from Mr. D. Hunter, superintendent of the above mentioned plant.

The total annual expenses relating to the boilers and engines and the portion of the building occupied by the same are summed up as follows :

Coal bill for fiscal year ending February 28th, 1898.....	\$12,102
Value of water used.....	500
Wages of engineers, firemen, etc.....	9,853
Proportional part of office expenses	1,400
Supplies and repairs.....	4,681
Interest on valuation of real estate and portion of building occupied by boilers and engines—5 per cent.....	2,225
Interest and depreciation on valuation of boilers, etc.—10 per cent	3,000
Interest and depreciation on valuation of engines, etc.—10 per cent.....	3,000
Total.....	<u>\$36,761</u>

The next step is to arrive at the indicated H. P. hours developed, which was done as follows: The plant ran daily for 11 hours at full load with a probable efficiency of 72.7 %, made up of the following efficiencies: Engines, 90 %; belting, 95 %; dynamos, 85 %.

For the remaining 13 hours the efficiency was probably about 65.4 %, made up of the following efficiencies: Engines, 87 %; belting, 94 %; dynamos, 80 %.

From data given in the report, it can be readily calculated that the output of the dynamos while running 11 hours at full load was 2,531,800 K. W. hours and 427,280 K. W. hours for the balance of the time.

Dividing the first by $.746 \times .727$ gives 4,668,000 H. P. hours developed by all the engines during 365 days, running daily 11 hours at full load.

Dividing 427,280 by $.746 \times .654$ gives 875,800 H. P. hours developed during the balance of the time. To the above we have to add the estimated output of the engines driving the exciters, which is 165,300 H. P. hours, which gives a total of 5,709,100 H. P. hours per annum. Dividing the amount of coal burned during the year which was 26,892,000 pounds, by the above, we obtain 4.7 pounds of coal burned per indicated H. P.

The average H. P. per day of 24 hours equals 652 H. P., and the cost per H. P. per annum for a day of 24 hours and 365 days per year is \$56.37. This figure is higher on account of the fact that the plant runs on a very small load for 13 hours

out of the 24. For the average working year of 308 days and 24 hours per day, the cost per annual H. P. equals \$47.57. We will consider this from one other standpoint. The power developed during the 13 hours of light load is just equivalent to that developed in two hours of full load. Working on this basis we would have an average H. P. per day of 13 hours equals 1,426 H. P., and the annual cost per H. P. per average working year of 308 days and 13 hours per day equals \$25.78.

This figure is of course higher than it would be owing to the fact that less coal would be burned for the straight run of 13 hours per day, the number of men employed would be less and the other general expenses would be somewhat less.

Having thus shown what would be the probable cost of power developed in the Allegheny City Electric Lighting Plant, it will be interesting to compare the results obtained by Mr. H. A. Foster in and around Buffalo, and which appear in a paper read before The American Institute of Electrical Engineers, July 27, 1897. As previously stated, this work was done for the Cataract Power Company to determine the actual cost of power and the values obtained are very interesting. We will only have time to give the best and worst results and an average on all the tests made. The cheapest power was obtained from a Corliss triple compound condensing engine of 1200 rated H. P. developing actually 1175 H. P. The engine ran for 306 days at 9½ hours per day, and the cost of per annual H. P. was \$15.69. The greatest cost of power was obtained from a plant which had one slide-valve engine, rated at 40 H. P. One compound automatic engine, rated at 65 H. P., actual power developed was 12.4 H. P. The engine ran for 361 days, 9 hours per day, and cost per annual H. P. \$173.33.

Taking the average of the 22 tests which were made under the direction of Mr. Foster, we obtain the following results: For 308 days, 16 hours per day, the annual H. P. amounts to \$71.86. For 308 days of 10 hours per day, the annual H. P.

amounts to \$44.90. Mr. Foster's report shows emphatically that the engines tested in most cases were not any way near working up to their normal capacity, and hence that the cost of power was generally higher than would be expected before his tests were made.

He also gives much valuable data based on the papers of Mr. Emery, which have appeared in technical journals from time to time, but it is not within the province of this paper to consider these now.

The United Electric Light & Power Company of New York City, report the following as the yearly record of their plant: $4\frac{1}{2}$ pounds per electric H. P. per hour, or 3.3 pounds of coal per indicated H. P. per annum. In "Engineering" (England), the following figures are given based on a 24 hour run, made by the government: 1.7 pounds best coal per indicated H. P.

We will close this rerort by giving the probable cost per annual H. P. developed by the use of natural gas, illuminating gas, gasoline, and coal, taking into consideration only the cost of fuel. These figures are based on the engine of about 50 H. P. capacity.

Natural Gas— $12\frac{1}{2}$ cubic feet consumed per H. P. per hour.

$12\frac{1}{2} \times 10 \times 300 = 37,500$ cubic feet, amount consumed in 1 year of 300 days and 10 hours per day.

Then $37,500$ cubic feet $\times 22\frac{1}{2}c = \7.43 cost per H. P. per year.

Illuminating Gas—18 cubic feet consumed per H. P. per hour.

$18 \times 10 \times 300 = 54,000$ cubic feet, amount consumed in 1 year of 300 days and 10 hours per day.

$54,000$ cubic feet $\times \$1.00 = \54.00 , cost per H. P. per year.

Gasoline— $\frac{1}{8}$ gallon consumed per H. P. per hour.

$\frac{1}{8} \times 10 \times 300 = 375$ gallons, amount consumed in 1 year of 300 days and 10 hours per day.

375 gallons \times 7c = \$26.25, cost per H. P. per year.

Coal—4 pounds consumed per H. P. per hour.

$4 \times 12 \times 300 = 14,400$ pounds consumed in 1 year of 300 days and 10 hours per day.

$7\frac{1}{2}$ net tons \times \$1.00 = \$7.20 cost per H. P. per year.

NOTE.—The reason 12 hours are used instead of 10 is on account of the time spent and coal used in banking fires.

INFORMATION RELATING TO COST OF PRODUCING POWER FOR
POWER COMMITTEE OF ENGINEERS' SOCIETY OF WEST-
ERN PENNSYLVANIA, 410 PENN AVENUE, PITTSBURG,
PA.

1. Name of firm—Allegheny City Electric Light Plant.
2. Where located—Corner Braddock and Irwin Avenues, Allegheny, Pa.
3. Nature of business—Electric light for municipal purposes.

NOTE.—Please fill out and return to H. W. Fisher, Westinghouse Building, Pittsburg, Pa., before September 31st, 1897.

If more than one plant, put in particulars of each plant on separate sheet if possible.

BOILERS.

4. How many boilers employed? Eight.
5. Type? (give in detail). Two Babcock & Wilcox 250 H. P. each; and size six R. T. 100 H. P. each, and whether set in battery or singly. B. & W. in one battery; R. T. in one battery.
6. Kind of fuel used? Slack; calorific, value of per lb. —.
7. Kind of grates? Roney machine stokers; and furnaces used? —; fuel economizer used? No.
8. Are mechanical stokers used? Yes; or hand firing? —.
9. Height of chimney? B. & W. 150 feet; R. T. stack 100 feet.

10. Is exhaust steam used for heating feed water? Yes.
11. Name and type of heater employed? Goubert.
12. Boiler pressure regularly used? 110 to 115 pounds.
13. Do you exhaust steam for any other purposes? —.

If so, state in full what use, and if possible what amount is so used? —.

14. Have you made boiler tests to determine the evaporation of feed water, and the consumption of fuel? No. If so, with what result? —.

15. What is the average evaporation of feed water per pound of fuel in actual running? Never measured.

16. What is the temperature of feed water? 200 degrees.

17. Is steam taken from your boilers for any other purposes than for engines reported? —; if so, state in full: Office radiator only.

18. Do you measure the amount of feed water used by boilers? No; and how? —.

19. How many hours per day are boilers in use? Alternately, about half for 11½-hour runs.

20. Can you state the amount of fuel used per day and night in banking fires? 1,200 pounds.

ENGINES.

21. How many steam engines do you employ? 19.

22. Give in detail the cylinder diameter, stroke, revolutions per minute, and rated horse power of each engine, stating whether automatic, cut off, or otherwise? 13 compound and 6 single engines. Compound—(a) one 18 and 30 × 16; (b) four 14 and 24 × 14; (c) seven 13 and 22 × 13; (d) one 10 and 18 × 10. Simple—(e) two 6¼ × 5; (f) four 4½ × 4 in.; stoker service. (a) 250 revolutions, 250 H. P.; (b) 285 revolutions, 150 H. P.; (c) 300 revolutions, 125 H. P.; (d) 310 revolutions, 75 H. P.; (e) 400 revolutions, 15 H. P.; (f) 5 H. P. All are Westinghouse automatic engines.

23. Do you use a condenser? No. What vacuum do you regularly obtain? —.

24. Is your power regular or fluctuating? Give details and nature of work it is used for. Varies as per time and weather. Electric lighting.

25. Have you made indicator tests to determine the horse power of engines? None of recent date.

26. What is the average daily, and maximum daily, horse power of engines? Six K. W. = 1 H. P.; 2,959,080 K. W. hours per annum \times 165,300 H. P. hours for stoker and excited engines. The engines run for 11 hours on full load and $\frac{1}{2}$ of the run at $\frac{3}{4}$ load for 13 hours.

27. What is the average consumption of fuel, per indicated horse power developed by engines, when at full load? —; also average per day per H. P. hour? —.

28. What is the back pressure on engines, when exhaust steam is employed for heating or other purposes? —.

29. How many hours per day are engines employed? Nearly all for 11 hours; $\frac{1}{2}$ for 13 hours.

30. How is the power applied? By direct driven belting.

INVESTMENT.

31. What is the capital invested in boiler plant, and its accessories, including feed water heaters, pipes, foundations, and chimneys, etc.? \$30,000.

32. What is the capital invested in engine plant, and its accessories, including foundations, pipes, etc.? \$30,000.

33. What is the capital invested in real estate and buildings occupied by engine and boiler plants? Real estate, occupied by boilers and engines, \$22,500; buildings, occupied by engines and boilers, \$22,000.

DEPRECIATION.

34. What is your estimate for the annual depreciation of value? For engine plant, 5%; for boiler, 5%.

35. What is the annual cost of repairs? [See 42.]

OPERATING EXPENSES.

36. What is your annual fuel bill? \$12,102; 13,446 tons per annum at 90c.; 40% more fuel is used proportionally during the light run of 13 hours than through the heavy run of 11 hours.

37. How many hours per annum is your plant in active operation? Continuously, with varying hours.

38. What is the cost of fuel per ton on your premises? 90 cents.

39. Have you had experience with other fuels? No.

40. What is the cost of water for your steam plant? No cost, but the amount used would cost \$500 per annum.

41. What is the annual expenditure for wages to employes to the plant? Engineers, \$3,120; boiler room, \$4,933; helpers, \$1,800; total, \$9,853.

42. What is the annual expenditure for supplies of all sorts for boiler, engine, hydraulic, air and electric plants? Cleaning, \$160; hardware and tools, \$200; boilers, \$93; engines, \$148; packing, \$545; furnaces, \$787; steam and water lines, \$386; pumps, \$84; buildings, \$393; blacksmith and machine work, \$250; insurance, \$533; miscellaneous, \$200; boiler inspection, \$30; oil, \$872; total, \$4,681.

43. What percentage of the general expenses of your business do you consider proper to apportion to power plant? \$1,400 for office work and part of Superintendent's time. And what does this amount to, expressed in dollars, per annum? \$1,400.

HENRY W. FISHER,	} Committee.
L. B. STILLWELL,	
WM. A. BOLE,	
D. ASHWORTH,	

MEETING OF CHEMICAL SECTION.

PITTSBURG, June 22, 1899.

The regular monthly meeting of the Chemical Section was held June 22, 1899, at 410 Penn Avenue. Chairman, E. S. Johnson. Attendance, 10.

The minutes of the last regular meeting were read and approved. Abstracts from recent chemical papers were read by Dr. F. C. Phillips and discussed informally by those present.

The committee on Chemical Literature presented a report embodying abstracts of recent papers upon chemical subjects, of which the following is a brief summary:

Synopsis of a Course of Study for Chemical Engineers. Beilby, Jour. Soc. Chem. Industry, April 29, 1899.

This paper deals at length with the subject of the training of young men who expect to enter positions as chemists in manufacturing establishments.

Progress in the Chemical Technology of Fibers. Gassman, Jour. Soc. Chem. Industry, April 29, 1899.

The paper discusses the qualitative detection and qualitative determination of various kinds of fiber in fabrics.

Constants of Marine Animal Oils. Fahrion, Chemiker Zeitung, 1899, page 23.

Average results are given of quantitative methods for testing such oils.

Preliminary Purification of Petroleum with Lime. Stepanow, Jour. Soc. Chem. Industry, 1899, page 359.

The author discusses the relative effects of lime and caustic soda in the refining of petroleum.

Deposits of Naphthalene Crystals in Gas Pipes. Eitner, Jour. Soc. Chem. Industry, 1899, page 356.

The use of benzene or xylene in carbureting gas may prevent this deposit, provided the temperature to which the vapor of these liquid hydrocarbons is exposed is not sufficient to cause their decomposition.

Purification of Acetylene by Chromic Acid Solution.

Ullmann, "Acetylene," 1899, page 28.

The necessity for the purification of acetylene is being recognized where the gas is introduced for lighting upon a large scale. Its purification proves to be more difficult than that of coal gas. Chromic acid used in a dry state or in solution has been found to be an efficient purifier.

The New Gases of the Atmosphere. Sothar Wöhler, Jour. Gasbel and Wasserversorgung, 1899, page 345.

The properties of these newly discovered elementary gases are discussed and interesting conclusions are given as to their position in the periodic system of elements.

The Chemistry of Acetylene. Erdmann, "Acetylene," 1898, page 153.

Exposed to a temperature of 400° to 500° Centigrade, in presence of copper, acetylene yields graphite. At a temperature of 230° copper or cuprous oxide yields, with acetylene, a new compound which is not explosive, and therefore unlike other metallic compounds of acetylene.

A specimen of this compound, which is of interest on account of its remarkable lightness, was exhibited by the committee.

These subjects were discussed generally by the members. The Section adjourned at 10 P. M.

A. G. McKenna,
Sec. C. S.

OFFICERS FOR 1899.

GENERAL SOCIETY.

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HARRY J. LEWIS.

VICE PRESIDENT.

W. A. BOLE,
Term expires 1900.

H. W. FISHER,
Term expires 1901.

DIRECTORS.

C. F. SCOTT,
Term expires 1900.
GUSTAVE KAUFMAN,
Term expires 1900.

P. T. BERG,
Term expires 1901.
F. C. PHILLIPS.
Term expires 1901.

SECRETARY.

REGINALD A. FESSENDEN.

TREASURER.

A. E. FROST.

CHEMICAL SECTION.

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A. G. McKENNA.

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W. R. MARDEN,	E. K. MORSE, SELWYN M. TAYLOR.

HOUSE COMMITTEE.

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F. Z. SCHELLENBERG,	CHAS. FITZGERALD, O. C. OPSION.

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R. A. ROWLAND,	JOHN M. PHILLIPS.

PAST PRESIDENTS.

Wm. Metcalf,	1880-1.	T. P. Roberts,	1891.
A. Gottlieb,	1882-3.	Alfred E. Hunt,	1892.
Wm. Miller,	1884.	M. J. Becker,	1893.
Geo. H. Browne,	1885.	T. H. Johnson,	1894.
E. B. Taylor,	1886.	Chas. Davis,	1895.
Alex. Dempster,	1887-9.	W. G. Wilkins,	1896.
J. A. Brashear,	1889.	Emil Swensson,	1897.
W. L. Scaife,	1890.	Geo. S. Davison,	1898.

PAST SECRETARIES.

James H. Harlow,	1880-2-3-4.	James H. Harlow,	1891.
W. F. Zimmerman,	1885.	R. N. Clark,	1892-3.
S. M. Wickersham,	1886-7-8-9-1890.	Daniel Carhart,	1894-5-6.
Reginald A. Fessenden, 1897-8.			

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

LIST OF MEMBERS.

AUGUST 1, 1899.

Members are particularly requested to keep the Secretary constantly informed as to their correct addresses.

HONORARY MEMBERS.

Name.	Occupation and Address.	Date of Election.
LANGLEY, J. W.,	Prof. of E. E. Case School of Applied Science, 77 Cornell St., Cleveland, Ohio.	M., Nov., 1888. H. M., May, 1893.
THOMPSON, BEN,	Asst. Eng. Southern Ry. Co., Highland Park, Tenn.	H. M., May, 1893.

MEMBERS.

(Names of Past Presidents are in Italics.)

Name.	Occupation and Address.	Date of Election.
ABBOTT, W. L.,	Manufacturer, Rm. 302 Bank of Com. Bldg., 543 Wood St., Pittsburg, Pa.	Dec., 1890.
AHLBERG, G. A. F.,	Mechanical Engineer for Wilson-Snyder Mfg. Co., Pittsburg, Pa. 222 Stratford Ave., Pittsburg, Pa.	April, 1898.
AHLEN, WILLIAM,	Chief Draughtsman, Duquesne Steel Works and Blast Furnaces, Care of Carnegie Steel Co., Duquesne, Pa.	April, 1899.
AIKEN, HENRY,	Consulting Mechanical Engineer, 403 Lewis Block, Pittsburg, Pa.	May, 1880.
ALBREE, CHESTER B.,	Manufacturer, 16-30 Market St., Allegheny, Pa.	Oct., 1885.
ALBREE, RALPH,	Partner of Chester B. Albree, Structural Iron and Riveting Machines, 187 Western Ave., Allegheny, Pa.	Feb., 1899.
ANDERSON, JOHN W.,	Gen. Mgr. Carbon Steel Co., Pittsburg, Pa. 45 Fremont St., Allegheny, Pa.	Dec., 1884.
ARMS, WALTER F.,	Supt. Eleanora Mines of the Rochester and Pittsburg Coal and Iron Co., Eleanora, Jefferson Co., Pa.	Jan., 1897.
ARMSTRONG, H. W.,	Gen. Mgr. Verona Tool Works, Verona, Pa.	Jan., 1880.
ARRAS, JOHN W.,	U. S. Asst. Engineer, Federal Building, P. O. Box 485, Pittsburg, Pa.	Nov., 1888.

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Name.	Occupation and Address.	Date of Election.
ARROTT, JR., JAMES W.,	Supt. Enamelling Dept., Standard Mfg. Co. 581 Preble Ave., Allegheny, Pa.	March, 1892.
ASCHMAN, FREDERICK T.,	Analytical and Consulting Chemist, Prof. of Chemistry, Pittsburg College of Pharmacy, W. U. of Penna., Chemist of Dept. of Agriculture of Penna., 419 Standard Bldg., Pittsburg, Pa.	April, 1896.
ASHMEAD, FRANK M.,	Resident Engineer, A. V. Ry. Co. 11th and Pike Sts., Pittsburg, Pa.	April, 1893.
ASHWORTH, A. KENNEDY,	Consulting Mechanical Engineer and Steam Expert, 349 Lehigh Ave., Pittsburg, Pa.	Dec., 1895.
ASHWORTH, DANIEL,	Consulting Engineer and Steam Expert, 326 Fourth Ave., Pittsburg, Pa.,	April, 1890.
ATWATER, R. M.,	Secy. Semet-Solvay Co., The Solvay-Process Co., Syracuse, New York.	April, 1896.
ATWOOD, JOHN A.,	Chief Engineer, P., & L. E. R. R. Beaver, Pa.	April, 1891.
AUEL, CARL. B.,	Engineer with Westinghouse Air Brake Co., Wilmerding, Pa., Care of Amber Club, E. E., Pittsburg, Pa.	April, 1899.
BAILEY, CHARLES,	Chairman Reliance Steel Casting Co., Ltd., 36th St. and A. V. R. R., Pittsburg, Pa.	Sept., 1897.
BAILEY, JAMES M.,	Managing partner of Phillips, Nimick & Co., P. O. Box 872, Pittsburg, Pa.	Sept., 1884.
BAILEY, JOHN M.,	Sec'y Pittsburg Testing Laboratory, Ltd., 325 Water St., Pittsburg, Pa.	June, 1892.
BAKEWELL, THOMAS W.,	Attorney-at-Law, Patent Attorney, Bakewell & Bakewell, Carnegie Building, Pittsburg, Pa.	May, 1884.
BALTZELL, WILL H.,	Mechanical Engineer, with Schoenberger & Co., Pittsburg, Pa.	Dec., 1892.
BARBOUR, GEO. H.,	Civil Engineer, Care of Fort Pitt Bridge Works, Canonsburg, Pa.	April, 1888.
BARR, LAWRENCE,	Telephone Engineer, with C. D. & P. Tel. Co. Pittsburg, Pa.	March, 1897.
BARRETT, J. C.,	Chief Chemist for The Ohio Steel Co. Youngstown, Ohio.	April, 1892.
BARTON, H. L.,	Asst. Supt. of Westinghouse Machine Co., East Pittsburg, Pa.	April, 1895.
BATES, ONWARD,	Engineer and Supt. Bridges & Buildings of C. M. & P. Ry., 1100 Old Colony Building, Chicago, Ills.	Nov., 1882.
BEAZELL, EDWIN H.,	Civil Engineer.	Nov., 1892.

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Name.	Occupation and Address.	Date of Election.
BECKFIELD, CHARLES,	Mechanical Engineer, 121 S. Third St., Steubenville, Ohio.	Jan., 1885.
BENNER, S. A.,	Sales Dept. Carnegie Steel Co., Ltd., Superior Ave., Allegheny, Pa.	Dec., 1895.
BENNEY, JAS.,	Supt. Philadelphia Co., Rm. 10 Westinghouse Building. Pittsburg, Pa.	Dec., 1883.
BERG, W. EDWARD,	Mechanical Engineer, with Jones & Laughlins, Ltd., 3411 Ward St., Pittsburg, Pa.	April, 1898.
BERG, P. T.,	Mechanical Engineer, with Carnegie Steel Co., Ltd., at Homestead Steel Works, Munhall, Pa.	Dec., 1892.
BERNARD, H. W.,	Mining Engineer and Chemist, with Carnegie Steel Co., Ltd., Pittsburg, Pa., 55 Wilson Avenue, Allegheny, Pa.	March, 1896.
BEUTNER, VICTOR,	Mechanical Engineer, Smith Building, Pittsburg, Pa.	Feb., 1896.
BIGELOW, E. M.,	Director of Department of Public Works, Pittsburg, Pa.	Jan., 1880.
BLACK, SAMUEL W.,	Real Estate Agent, S. W. Black & Co., 318 Fourth Ave., Pittsburg, Pa.	March, 1891.
BODEN, DANIEL,	Supt. Mansfield Coal and Coke Co., Carnegie, Pa.	March, 1895.
BOLE, WM. A.,	Supt. Westinghouse Machine Co., East Pittsburg, Pa., 5512 Howe St., Pittsburg, Pa.	March, 1884.
BONAR, JAMES,	Mechanical Engineer and Manager, James Bonar & Co., 1216 Carnegie Bldg., Pittsburg, Pa.	March, 1899.
BOWMAN, A. M.,	Mahan P. O., Beaver County, Pa.	Oct., 1895.
BOWMAN, F. M.,	Engineer, Structural Iron Works, Ritter-Conley Mfg. Co., Allegheny, Pa.	April, 1893.
BRADFORD, WILLIAM,	Civil Engineer, 341 Fourth Ave., 142 S. Negley Ave., Pittsburg, Pa.	March, 1893.
BRAKES, JAMES,	Chemist for Chateaugay Ore & Iron Co., Lyon Mountain, Clinton Co., New York.	April, 1892.
Brashear, John A.,	Astronomical and Physical Instrument Manufacturer, 260 Perrysville Ave., Allegheny, Pa.	March, 1884.
BROWN, ALBA FISK,	271 40th St., Pittsburg, Pa.	April, 1893.
Browne, Geo. H.,	General Manager Philadelphia Co., Second Floor, Westinghouse Building, Pittsburg, Pa.	Jan., 1880.
BROWN, W. R.,	Civil Engineer, City Hall, Pittsburg, Pa.	Jan., 1880.

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Name.	Occupation and Address.	Date of Election.
BRYAN, CHARLES W.,	Chief Engineer Edge Moor Bridge Works, Edge Moor, Delaware.	March, 1894.
BRYNN, PIERRE,	Shiffler Bridge Co., Pittsburg, Pa.	March, 1892.
BUENTE, C. F.,	Buente & Martin, 10th St. & Duquesne Way, Pittsburg, Pa., Stone and Brick Contractor, Perryville Ave. and Charles St., Allegheny, Pa.	Jan., 1887.
CADMAN, A. W.,	Pres. Cadman Mfg. Co., 63 Water St., Pittsburg, Pa.	Jan., 1886.
CAMP, J. M.,	Metallurgical Engineer and Chemist for Duquesne Steel Works, and Blast Furnaces of Carnegie Steel Co., Ltd., Duquesne, Pa.	May, 1882.
CARD, W. W.,	Sec'y Westinghouse Air Brake Co., P. O. Box 273, Pittsburg, Pa.	June, 1892.
CARHART, DANIEL,	Dean and Professor of Civil Engineering at W. U. of P., Allegheny, Pa., 1410 Centre St., Station "D," Pittsburg, Pa.	Feb., 1883.
CARLIN, T. H.,	Manufacturer, 181 Robinson St., Allegheny, Pa.	May, 1885.
CARNEGIE, ANDREW,	5 West 51st St., New York.	April, 1880.
CHAMBERS, JR., J. S.,	Civil Engineer, 19 Church Ave., Allegheny, Pa.	Sept., 1883.
CHESS, H. B.,	531 Wood St., Pittsburg, Pa.	Feb., 1880.
CHESTER, D. HERBERT,	Pittsburg Sales Manager for Henry R. Worthington Co., 317 Third Ave., Pittsburg, Pa.	Feb. 1899.
CHESTER, J. N.,	Pittsburg Sales Manager for Henry R. Worthington Co., 317 Third Ave., Pittsburg, Pa.	Dec., 1896.
CLAPP, G. H.,	Chairman Pittsburg Testing Laboratory, Limited, 325 Water St., Pittsburg, Pa.	Nov., 1882.
CLIFFORD, WILLIAM,	Mining Engineer (Ventilation), 232 Fifth Ave., Pittsburg, Pa.	Jan. 1899.
COFFIN, JR., W. C.,	N. Y. Mgr. for Ritter-Conley Mfg. Co., 39 Cortlandt St., New York.	Oct., 1883.
CONNELLEY, C. B.,	Principal Manual Training School of Allegheny, Pa., Page and Fulton Sts., 5th Ward School, Allegheny, Pa.	May, 1891.
CONNER, W. A.,	Gen. Supt. Standard Underground Cable Co., Pittsburg, Pa., 10 Oakland Square, Pittsburg, Pa.	March, 1897.
COOPER, C. A.,	Civil Engineer, 410 Grant Street, Pittsburg, Pa.	Feb., 1881.
COOPER, FRANK IRVING,	Architect, Wayland, Mass.	April, 1892.

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
COREY, W. E.,	Genl. Supt. Homestead Steel Works of Carnegie Steel Co., Ltd., Munhall, Pa.	Nov., 1897.
CORNELIUS, W. A.,	Supt. of 23-in., 28-in. and 10-in. Structural Mills, Homestead Steel Works, of Carnegie Steel Co., Ltd., Munhall, Pa.	Nov., 1889.
COSTER, W. H.,	Chemist, 4502 Fifth Ave., Pittsburg, Pa.	April, 1892.
COVELL, VERNON R.,	Civil Engineer with County Engineer of Allegheny Co., Pittsburg, Pa. 440 Rebecca Ave., Wilkinsburg, Pa.	Nov., 1897.
CRAWFORD, DAVID F.,	Asst. Supt. Motive Power, Penna. Lines West of Pittsburg, Pa., (care of Penna. Co., Ft. Wayne, Ind.)	June, 1899.
CROOKER, JR., RALPH,	Mechanical Engineer, with Jones & Laughlins, Ltd., S. E., Pittsburg, Pa.	March, 1896.
CUNNINGHAM, E. W.,	Civil Engineer, 1637 Indiana Ave., Chicago, Ill.	March, 1896.
CUNNINGHAM, JNO. M.,	Civil Engineer and Contractor, with Schultz Bridge & Iron Co., Ltd., 601-2 Hamilton Bldg., Pittsburg, Pa.	Dec., 1896.
CURRY, H. M.,	Mgr. Carnegie Steel Co., Carnegie Building, Pittsburg, Pa.	Sept. 1880.
DAFT, L. J.,	Constructing Engineer, with Ingersoll, Sergeant Drill Co., Cleveland, Ohio, 26 South Water St., Cleveland, Ohio.	Sept., 1897.
Davis, Charles,	County Engineer, Court House, Pittsburg, Pa.	Jan., 1880.
DAVIS, H. P.,	Electrical Engineer, with The Westinghouse Electric and Mfg. Co., East Pittsburg, Pa. 327 Neville St., Pittsburg, Pa.	Dec., 1898.
Davison, G. S.,	Civil Engineer, Wilkins & Davison, Rm. 91 Westinghouse Building, Pittsburg, Pa.	Dec., 1880.
DEFORTH, J. M.,	Civil Engineer, Pittsburg Bridge Co., 38th St. and A. V. R., Pittsburg, Pa.	Feb., 1891.
Dempster, Alex.,	Pres. Pittsburg Wire Co., 232 Fifth Ave., Pittsburg, Pa.	Jan., 1880.
DIESCHER, SAMUEL,	Civil and Mechanical Engineer, Rm. 714 Hamilton Building, Pittsburg, Pa.	Jan., 1880.
DINKEY, ALVA C.,	Supt. Electrical Dept. Homestead Steel Works, of Carnegie Steel Co., Ltd., Munhall, Pa.	Nov., 1897.
DRAVO, EDWARD T.,	Member of firm of C. G. Hussey & Co., 12 Sherman Ave., Allegheny, Pa.	Oct., 1890.
DUBES, J. A.,	The Mexican Sulphur Co., 1942 Forbes St., Pittsburg, Pa.	Dec., 1892.

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Name.	Occupation and Address.	Date of Election.
DUCKHAM, A. E.,	Civil Engineer, 232 Rebecca St., E. E., Pittsburg, Pa.	March, 1892.
DUDLEY, C. B.,	Chemist, P. R. R. Co., Altoona, Pa., (Drawer 334.)	April, 1892.
ECKERT, E. W.,	452 W. 153d St., New York.	Jan., 1881.
EDEBURN, W. A.,	Civil Engineer, Edeburn & Cooper, 410 Grant St., Pittsburg, Pa.	Jan., 1880.
EHLERS, C. W.,	Assist. Engineer, Bureau of Engineering and Surveys, City of Allegheny, Pa., 163 Lowrie St., Allegheny, Pa.,	March, 1896.
ELLIOTT, J. R.,	Civil Engineer, with Wilkins & Davison, Rm. 91 Westinghouse Building, Pittsburg, Pa.	March, 1896.
ENGEL, G. U.,	Assist. Engineer, P., C., C. & St. L. Ry., General Offices Penna. Company, 10th St. & Penn Ave., Pittsburg, Pa.	Feb., 1888.
ENGSTRÖM, FRANS,	Asst. Engineer, Dept. Public Works, Pittsburg, Pa. Highland Park, Pittsburg, Pa., 3721 Bouquet St., Pittsburg, Pa.	Sept., 1882.
ERICKSON, EDWARD E.,	Engineer and Contractor, Conestoga Bldg., Pittsburg, Pa.	April, 1898.
ESTRADA, E. D.,	Mechanical Engineer, Rm. 701 Lewis Block, Pittsburg, Pa.	Feb., 1898.
EVANS, RAWDON,	Purchasing Agent, P. & L. E. R. R. Co., Rm. 804 Bank of Commerce Building, Pittsburg, Pa.	March, 1893.
FARRAR, C. J.,	Engineer and Contractor, The Loraine Steel Co., Johnstown, Pa.	Feb., 1892.
FAWCUS, THOS.,	Supt. of R. D. Nuttall Co., Allegheny, Pa.	Jan., 1896.
FAWELL, JOSEPH,	Mackintosh, Hemphill & Co., Pittsburg, Pa., 312 Denniston Ave., E. E., Pittsburg, Pa.	March, 1899.
FERRARA, PETER,	Engineer with Wisconsin Bridge Co., 228 Tenth St., Milwaukee, Wis.	Feb. 16, 1897.
FESSENDEN, REGINALD A.,	Prof. of Electrical Engineering, Western University of Pa., Allegheny, Pa. Consulting Electrical Engineer (Fessenden & Ridinger), 410 Penn Ave., Pittsburg, Pa.	June, 1894.
FISHER, H. W.,	Electrical Engineer for Standard Underground Cable Co., 16th and Pike Sts., Pittsburg, Pa.	Jan., 1895.
FITZGERALD, CHARLES,	Supt. Consolidated Traction Co., 316 Evaline St., Pittsburg, Pa.	Jan., 1896.
FLANAGAN, G. E.,	Chief Draughtsman, Hydraulic Machine Co., 54th St., Pittsburg, Pa., 143 Home Street, Pittsburg, Pa.	June, 1894.

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
FLINT, WM. P.,	Mechanical Engineer with Westinghouse Machine Co., East Pittsburg, Pa., P. O. Box 224, East Pittsburg, Pa.	April, 1898.
FOHL, W. E.,	Mining Engineer, Masontown, Pa.	Jan., 1897.
FRANK, I. W.,	Pres. and Gen. Mgr. Frank-Kneeland Machine Co., 54th St. and A. V. R. R., Pittsburg, Pa.	Feb., 1882.
FRIEDLAENDER, EUGENE,	Electrical Engineer, with Carnegie Steel Co., Ltd., Duquesne Steel Works and Blast Furnaces, Duquesne, Pa.	April, 1897.
FROHMAN, E. D.,	Chemist for O. Hommel & Co., 32d St. and Penn Ave., Pittsburg, Pa.	April, 1896.
FROST, A. E.,	Prof. of Physics, Western University of Penna., Allegheny, Pa.	Jan., 1880.
FULTON, L. B.,	Pres. Chaplin-Fulton Kfg. Co., Bell Brass Founders and Machinists, 34 Penn Ave., Pittsburg, Pa.	April, 1888.
GARRIGUES, W. E.,	Consulting Chemical Engineer, Loomis, Washington.	May, 1895.
GEDDIE, ROBERT,	Salesman with Jones & Laughlins, Ltd., Pittsburg, Pa., Care of Jones & Laughlins, Ltd., Pittsburg, Pa.	May, 1899.
GAYLEY, JAMES,	Engineer with Carnegie Steel Co., Ltd., Pittsburg, Pa.	Jan., 1899.
GIBSON, HARRY W.,	Patton & Gibson, General Contractors, 531 Wood St., Pittsburg, Pa. 27 Fifth Ave., Pittsburg, Pa.	Jan., 1899.
GILFILLAN, GEO. A.,	General Engineer, 341 Fourth Ave., Pittsburg, Pa.	June, 1899.
GILLESPIE, T. A.,	Pres. the T. A. Gillespie Co., Westinghouse Building, Pittsburg, Pa.	March, 1897.
GLAFEY, F. A.,	Engineer of Bridges, Carnegie Steel Co., Ltd., Keystone Bridge Works, 51st St., Pittsburg, Pa.	Oct., 1883.
GLASS, G. G.,	Chemist LaBelle Steel Works, Allegheny, Pa.	March, 1892.
GOLDIE, WILLIAM,	Mechanical Expert, with Dilworth, Porter & Co., P. O. Box 575, Wilkinsburg, Pa.	Nov., 1894.
GOODYEAR, S. W.,	With Crescent Steel Co., Waterbury, Conn.	Feb., 1880.
GOW, A. M.,	East Pittsburg Gas Works, East Pittsburg, Pa.	Jan., 1895.
GRANT, H. E.,	Chairman of Oliver P. Scaife & Co., Ltd., Chatsworth Ave., Hazelwood, Pa.	June, 1885.

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Name.	Occupation and Address.	Date of Election.
GREENWOOD, G. F.,	Chief Engineer and General Manager Consolidated Traction Co., Pittsburg, Pa., Times Building, Pittsburg Pa.	Oct., 1892.
GREENWOOD, MICHAEL,	Agent for Laidlaw, Dunn, Gordon Co., Carnegie Bldg., Pittsburg, Pa., 16 Bayne Ave., Bellevue, Pa.	March, 1899.
GROSS, ABRAHAM,	Student Western University of Penna., Allegheny, Pa., 26 Allegheny Ave., Allegheny, Pa.	Feb., 1898.
GWINNER, JR., FRED,	General Contractor, 192 Market St., Allegheny, Pa.	Sept., 1882.
HACKETT, G. W.,	National Cement Co., 1009 Liberty Ave., Pittsburg, Pa.	March, 1883.
HAMILTON, THOMAS G.,	Engineer, Street Railway Construction, 5912 Marguerette St., Pittsburg, Pa.	Jan., 1899.
HALLGREN, EMIL,	Mechanical Engineer, Pittsburg, Pa.	Feb., 1891.
HANDY, J. O.,	Chief Chemist Pittsburg Testing Laboratory, Ltd., 325 Water St., Pittsburg, Pa.	Nov., 1896.
HARDIE, J. B.,	Engineer, with Carnegie Steel Co., Ltd., 503 Carnegie Bldg., Pittsburg, Pa.	Feb., 1891.
HARLOW, G. R.,	Civil Engineer, Station "D," Pittsburg, Pa.	April, 1881.
HARLOW, JAS. H.,	Jas. H. Harlow & Co., Hydraulic Engineers, Station "D," Pittsburg, Pa.	Jan., 1880.
HARRISON, A. B.,	Chemist Clinton Iron and Steel Co., 7 LaBelle St., S. S., Pittsburg, Pa.	March, 1892.
HAYS J. A.,	147 South 18th St., Pittsburg, Pa.	Feb., 1893.
HAYS, W. H.,	Chairman Iron City Tool Works, 32d and Smallman Sts., Pittsburg, Pa.	Oct., 1892.
HEFFRIN, HARRY,	Electrical Engineer and Draughtsman, Care of F. R. Dravo & Co., Lewis Bld., Pittsburg, Pa.	Jan., 1890.
HEMPHILL, JAMES,	President Mackintosh, Hemphill & Co., Foot 12th St., Pittsburg, Pa.	Jan., 1880.
HENRY, W. D.,	Sec'y Pittsburg Terra Cotta Lumber Co., Rm. 816 Carnegie Building, Pittsburg Pa.	April, 1893.
HERRING, E. A.,	Civil Engineer, 272 Fisk St., Pittsburg, Pa.	April, 1896.
HERRON, W. A.,	Real Estate, W. A. Herron & Son, Wood St., Pittsburg, Pa., 4837 Fifth Ave., Pittsburg, Pa.	Oct., 1892.
HERSCHMANN, ARTHUR,	Engineer, Schmerlinghof, Brunn, Austria.	March, 1899.

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
HIRSCH, RICHARD,	Draughtsman, with H. K. Porter & Co., 49th St., 1318 Fifth Ave., Pittsburg, Pa.	Dec., 1894.
HOAG, JR., I. V.,	U. S. Asst. Eng., Federal Building, Pittsburg, Pa. 170 South Ave., Allegheny, Pa.	Nov., 1888
HODGKINSON, FRANCIS,	Engineer, with Westinghouse Machine Co., East Pittsburg, Pa., 465 Ella St., Station "D," Pittsburg, Pa.	April, 1897.
HOHL, L. J.,	Civil Engineer, with Wilkins & Davison, 100 Boggs Ave., Mt. Washington, Pittsburg, Pa.	Sept., 1888.
HOLLAND, W. J.,	Chancellor Western University of Pennsylvania. Fifth Ave., Oakland, Pittsburg, Pa.	Dec., 1888.
HOLMES, A. G.,	Sec. Pittsburg Meter Co. East Pittsburg, Pa.	March, 1894.
HOUSE, F. E.,	Gen'l Supt. P. B. & L. E. R. R. Co., Carnegie Bldg., Pittsburg, Pa., Beaver, Pa.	March, 1892.
HUBER, S. V.,	Consulting Engineer, 702 Ferguson Block, Pittsburg, Pa.	Dec, 1895.
HUNKER, WILLIAM J.,	Supt. South Bend Electric Co., South Bend, Ind. P. O. Box 144, South Bend, Ind.	April, 1898.
HUNTER, JR., DAVID,	Supt. Allegheny City Light Plant, Allegheny, Pa.	April, 1898.
HUSSEY, C. G.,	Curran & Hussey, Engineers and General Contractors, 307 Hussey Bldg., Pittsburg, Pa.	June, 1893.
HYDE, CHAS.,	Consulting Mechanical Engineer, Room 902 Lewis Block, Pittsburg, Pa.	Oct., 1887.
ISAACS, A. S.,	Chemist, 1214 Sheffield St., Allegheny, Pa.	Nov., 1897.
JAMES, REES,	Supt. Open Hearth Dept. The Carnegie Steel Co. Ltd., Homestead Steel Works, Munhall, Pa.	March, 1899.
JENKS, I. WALTER,	Supt. La Belle Steel Works, 139 Locust St., Allegheny, Pa.	March, 1899.
JAMISON, W. W.,	Supt. The Penn Mining Co., Seattle, Washington.	Sept., 1893.
JENKINS, J. B.,	Civil Engineer, Topographical Draughtsman, Dept. of Street Improvements, 23d and Warden, New York City. 134 W. 127th St., New York City.	Dec., 1888.
JOHNSON, C. M.,	Analytical Chemist, with Park Bros. & Co., Box 101, Avalon, Pa.	April, 1892.

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Name.	Occupation and Address.	Date of Election.
JOHNSON, E. S.,	Chemist Director of Laboratory of the Black Diamond Steel Co., Pittsburg, Pa., care Park Steel Co., Pittsburg.	April, 1895.
Johnson, T. H.,	Chief Engineer P. C., C. & St. L. Ry., 10th St. and Penn Ave., Pittsburg, Pa.	Jan., 1888.
JONES, B. F.,	Jones & Laughlins, Ltd., South Side, Pittsburg, Pa.	April, 1881.
JONES, W. L.,	Jones & Laughlins, Ltd., South Side, Pittsburg, Pa.	March, 1888.
KARCH, JOSEPH P.,	Draughtsman, with Westinghouse Machine Co., East Pittsburg, Pa. Amber Club, Pittsburg, Pa.	April, 1898.
KAUFMAN, GUSTAVE,	Consulting Engineer and Contractor, 812 Hamilton Building, Pittsburg, Pa.	Nov., 1880.
KAY, JAS. I.,	Kay & Totten, Attorney at Law and Patent Solicitor, 426 Diamond St., Pittsburg, Pa.	Feb., 1885.
KELLER, CHAS.,	Chemist, 113 Biddle Ave., Station "D," Pittsburg, Pa.	March, 1895.
KELLER, E. E.,	Vice President and General Manager Westinghouse Machine Co., East Pittsburg, Pa. Edgewood Park, Pa.	April, 1895.
KELLEY, J. A.,	28th and Smallman Sts., Pittsburg, Pa.	March, 1885.
KELLEY, J. W.,	Contractor, P. O. Box 13, Joplin, Mo.	Jan., 1885.
KELLEY, M. B.,	Salesman and Auditor, Zug & Co., Ltd., 7 Wylie Ave., Pittsburg, Pa.	Oct., 1891.
KEMERY, PHILO,	Chemist, Crescent Steel Works, 51st St. and A. V. R. R., Pittsburg, 227 Fisk St., Pittsburg, Pa.	April, 1892.
KEMLER, W. H.,	1823 Carson St., Pittsburg, Pa.	Feb., 1891.
KENNEDY, DAVID S.,	Supt. of Rolling Mill, The Carnegie Steel Co., Ltd., Homestead Steel Works, Munhall, Pa.	June, 1899.
KENNEDY, JULIAN,	Mechanical Engineer, Smith Bldg., Pittsburg, Pa.	May, 1886.
KIMBALL, F. I.,	Civil Engineer, Supt. Ocean Coal Co., Hermine, Pa.	June, 1888.
KING, T. M.,	Care Pittsburg & Western Ry., Allegheny, Pa.	Feb., 1882.
KIRK, ARTHUR,	Arthur Kirk & Son, 910 Duquesne Way, Pittsburg, Pa.	March, 1882.

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
KIRTLAND, A. P.,	Sec. Marble Hill Quarry Co., Rm. 1206 Carnegie Building, Pittsburg, Pa.	Nov., 1887.
KLINGELHOFFER, G. E.,	Supt. Atwood & McCaffrey, Pittsburg, Pa. 5515 Howe St., E. E., Pittsburg, Pa.	Dec., 1895.
KNOTTS, GEO. W.,	With Lincoln Foundry Co., Butler and 60th Sts., Pittsburg, Pa.	April, 1899.
KNOX, FRANCIS H.,	Electrical Engineer, Peoples Light, Power and Ry. Co., Spartanburg, S. C.	June, 1899.
KNOX, WILLIAM J.,	Chemist for Geo. Westinghouse, 820 Penn Avenue, Pittsburg, Pa.	Feb., 1899.
KOCH, W. E.,	Sharpsburg, Pa.	April, 1887.
LAMB, GEO.,	Government Printing Office, Washington, D. C.	Feb., 1892.
LANGE, P. A.,	Supt. W. E. & Mfg. Co., East Pittsburg, Pa.	Oct., 1896.
LANGENHEIM, G. C.,	Civil Engineer, Supt. Bureau of Engineering and Survey, City Engineer's Office, Allegheny, Pa.	Feb., 1896.
LASH, H. W.,	Manager Carbon Steel Co., Pittsburg, Pa.	Oct, 1892,
LAUDER, GEO.,	Carnegie Steel Co., Rm. 325 Carnegie Building, Pittsburg, Pa.	May, 1885.
LAUGHLIN, ALEX.,	Furnace Contractor and Engineer, Mechanical Engineer of Alex. Laughlin & Co., Rm. 706 Lewis Block, Pittsburg, Pa.	Feb., 1893.
LAWRENCE, C. K.,	Engineer, M. W. Union R. R., 1006 Carnegie Bldg., Pittsburg, Pa.	Jan., 1899.
LE PONTOIS, LEON,	Electrical Engineer, 608 Lincoln Ave., E. E., Pittsburg, Pa.	Oct., 1893.
LEAF, JAMES P.,	City Engineer of Rochester, Freedom and Monaca, Rochester, Pa.	Feb., 1899.
LEWIS, HARRY J.,	Civil Engineer, Times Building, Pittsburg, Pa.	May, 1890.
LEWIS, J. L.,	President of the Lewis Foundry and Machine Co., Ltd., 10th St., South Side, Pittsburg, Pa.	March, 1880.
LOEFFLER, G. O.,	Chemist of Carbon Steel Co., Pittsburg, 153 Pearl St., Pittsburg, Pa.	April, 1892.
LOOMIS, DE WAYNE,	Crafton, Pa.	March, 1894.

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Name.	Occupation and Address.	Date of Election.
LUTY, B. E. V., Editor Tin & Terne, Mgr. Pittsburg Office Iron Trade Review of Cleveland, Ohio, 53 Ninth St., Pittsburg, Pa.		Feb., 1899.
LYNCH, TILLMAN D., Asst. Inspector U. S. Navy, Upper Union Mill, 33d St., Pittsburg, Pa.		Feb., 1898.
LYNNE, MISS MARY L., Chemist to American Reduction Co., 1514-1526 Second Ave., 4621 Forbes St., Pittsburg, Pa.		March, 1893.
LYONS, J. K., Engineer in charge Bridge Detailing, Keystone Bridge Works, Carnegie Steel Co., Ltd., 214 Mathilda St., Pittsburg, Pa.		March, 1892.
MACBETH, G. A., Pres. Geo. A. Macbeth Co., Rm. 311 Telephone Building, Pittsburg, 717 Amberson Ave., Pittsburg, Pa.		Jan., 1880.
MACK, J. S., Mining Engineer for Coulter & Huff and Carbon & Hempfield Coal Companies, Greensburg, Pa.		April, 1897.
MACKENZIE, JAS., Carnegie Steel Co., Ltd., 406 Carnegie Building, Pittsburg, Pa.		Nov., 1892.
MANNING, W. T., Chief Engineer, B. & O. R. R., B. & O. R. R., Baltimore, Maryland.		March, 1892.
MARDEN, W. R., Engineer, The Pittsburg Bridge Co., 38th St., and A. V. R. R., Pittsburg, 5167 Penn Ave., Pittsburg, Pa.		May, 1896.
MARSHALL, C. D., Secy. and Engineer Shiffler Bridge Co., 141 Fairmount Ave., E. E., Pittsburg, Pa.		May, 1896.
MARSHALL, G. D., Asst. Inspector of Steel, U. S. N., Bethlehem Iron and Steel Co., South Bethlehem, Pa.		Jan., 1897.
MARTIN, WILLIAM, U. S. Asst. Engineer, 14 Sprague Ave., Bellevue, Pa.		Jan , 1880.
MATHISEN, CHRISTEN, Engineer, Raadhugaden 25 III, Christiansa, Norway.		Jan., 1896.
MERCADER, CAMILLE, Andrasig Strasse 23, Budapest, Hungary.		Sept., 1890.
MESTA, GEORGE, Pres. Leechburg Foundry and Machine Co., Rm. 708 Lewis Block, Pittsburg, Pa.		March, 1888.
Metcalf, William, Consulting Engineer, 208 Ferguson Block, Pittsburg, Pa.		Jan., 1880.
MEYRAN, L. A., Sec. and Treas., Canonsburg Iron & Steel Co., Rm. 405 German Savings Bank Building, Pittsburg, P. O. Box 954, Pittsburg, Pa.		Jan., 1884.
MILLER, H. B., 567 Jones Ave., Braddock, Pa.		March, 1893.
MILLER, HENRY F., Mechanical Engineer, with National Tube Works Co., McKeesport, Pa.		Jah., 1898.

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Name.	Occupation and Address.	Date of Election.
MILLER, WILSON,	Pres. Pittsburg Locomotive and Car Works, 18 Lincoln Ave., Allegheny, Pa.	May, 1885.
MILLIKEN, A. C.,	Pottsville Iron and Steel Co., Pottsville, Pa.	Oct., 1880.
MOHR, JACOB A.,	Chemist, with Carnegie Steel Co., Ltd., Duquesne Steel Works, Duquesne, Pa.	Jan., 1897.
MOLDENKE, R. G. G.,	Metalurgical Engineer for Pennsylvania Malleable Co., 510 Tradesmen's Bldg., Pittsburg, Pa. McCandless & Stanton Aves., Pittsburg, Pa.	Oct., 1899.
MOORHEAD, DAVID L.,	Civil Engineer and Surveyor, Indiana, Pa.	Jan., 1898.
MORGAN, THOMAS R.,	Late Gen'l Mgr. Morgan Engineering Co., 1404 New England Bldg., Cleveland, Ohio.	March, 1898.
MORRISON, THOS.,	Gen. Supt. Edgar Thompson Steel Works and Furnaces, The Carnegie Steel Co., Ltd., Braddock, Pa.	April, 1893.
MORSE, E. K.,	Civil Engineer, Rm. 1206 Carnegie Building, Pittsburg, Pa.	Jan., 1896.
MUELLER, GUSTAVE,	Chemist, 278 Howard St., Allegheny, Pa.	March, 1890.
MUNROE, ROBT.,	R. Munroe & Sons, Boiler Manufacturers, 23d and Smallman Sts., Pittsburg, Pa.	April, 1880.
MCCLELLAND, E. S.,	Chief Draughtsman Westinghouse Machine Co., East Pittsburg, Pa., Baxter St., near Brushton Ave., Pittsburg, Pa.	April, 1895.
MCALLEN, WM. J.,	Draughtsman, 36 Astor St., Chicago, Ill.	Jan., 1898.
MCCCLINTIC, HOWARD H.,	Ast. Gen. Mgr. Shiffler Bridge Co., 46th St. and A. V. R. R., Pittsburg, Pa.	Oct., 1892.
MCCCLINTOCK, H. P.,	Manufacturer, McC lintock & Irvine, South Ave. and Snowden St., Allegheny, Pa.	Jan., 1891.
MCCONNELL, J. A.,	203 Water St., Pittsburg, Pa.	May, 1885.
MCCRICKART, J. MONT.,	Mining Engineer with Selwyn M. Taylor, 347 Fifth Ave., Pittsburg, Pa.	Jan., 1898.
MCDONALD, F. A.,	Civil and Mining Engineer, Rm. 811 Penn Building, Pittsburg, Pa.	March, 1895.
MCDONALD, THOS. M.,	General Supt. The Ohio Steel Co., Youngstown, Ohio. 307 Madison Ave., Youngstown, Ohio.	March, 1893.
MCDONOUGH, JOHN,	S. Broadway, Joliet, Ill.	March, 1898.

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Name.	Occupation and Address.	Date of Election.
MCGARY, DANIEL,	Master Mechanic for J. Painter & Sons' Co., S. E., Pittsburg, 20 Meriden St., Duquesne Heights, Pittsburg, Pa.	March, 1892.
MCGARY, E. L.,	Asst. Mgr. A. Garrison Foundry Co., Pittsburg, Pa., 20 Meriden St., Duquesne Heights, Pittsburg, Pa.	May, 1897.
McKAIG, T. B.,	Sec'y Trade Dollar Mining and Milling Co., Rm. 822 Carnegie Building, Pittsburg, Pa.	Jan., 1891.
McKELVY, J. P.,	Chemist, with Mackintosh, Hemphill & Co., Pittsburgh, Pa.	March, 1892.
McKENNA, A. G.,	Chemist, Firth-Sterling Steel Co., Demmler, Pa.	April, 1892.
McKINLEY, ROBERT M.,	Signal Engineer, with Penna. Lines West of Pittsburg, 436 Rebecca St., Pittsburg, Pa.	April, 1898.
McLAUGHLIN, ROBERT,	Draughtsman, with Westinghouse Machine Co., East Pittsburg, Pa., 318 St. Clair St., Pittsburg, Pa.	April, 1899.
McLEOD, JOHN,	Engineer of Tests, Carnegie Steel Co., Ltd., Carnegie Building, Pittsburg, Pa.	March, 1897.
McMURTRY, G. G.,	Pres. Apollo Iron & Steel Co., P. O. Box 147, Pittsburg, Pa.	Feb., 1882.
McNAUGHER, DAVID W.,	Civil Engineer, Inspection and Tests, Halsted & McNaugher, 1417 Park Building, Pittsburg, Pa.	Dec., 1896.
McQUISTON, JAMES,	Jas. McQuiston & Co., 26th and Railroad Sts., Pittsburg, Pa.	Feb., 1885.
NAEGLEY, JOHN,	Architect and Engineer, Rm. 713 Hamilton Building, Pittsburg, Pa.	Jan., 1880.
NEELAND, M. A.,	Mechanical Engineer, with The Ohio Steel Co., Youngstown, Ohio.	May, 1894.
NESBIT, JOSEPH M.,	Attorney-at-Law and Solicitor of Patents, 704 Park Bldg., Pittsburg, Pa.	June, 1899.
NICHOLS, C. H.,	Civil Engineer, with Post & McCord, 401 St. Nicholas Ave., New York, N. Y.	Nov., 1891.
NICHOLS, COL. T. B.,	Retired Officer of U. S. Army, 8 Oak St., Plattsburg, N. Y.	Jan., 1880.
NOBLE, PATRICK,	Gen. Mgr. The Pacific Rolling Mill Co., San Francisco, Cal., 100 Market St., San Francisco, Cal.	Feb., 1882.
NURICK, ALEXANDER,	Chief Draughtsman of Structural Department, Jones & Laughlins, Ltd., South Side, Pittsburg, Pa.	Nov., 1892.
OTTO, HENRY,	Master Mechanic to Shoenberger Steel Co., Pittsburg, Pa.	April, 1899.

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
PAGE, GEORGE S.,	Supt. P. B. & Co., Ltd, Care Park Steel Co., Ltd., Pittsburg, Pa.	Nov., 1892.
PANCOAST, ALBERT,	Chief of Bureau of Inspection of Schoen Pressed Steel Co., Woods Run, Allegheny, Pa.	March, 1897.
PALMER, W. P.,	Second Vice-Pres. Illinois Steel Co., The Rookery, Chicago, Ill.	Nov., 1888.
PARKIN, CHAS.,	With Crescent Steel Co., New Kensington, Pa.	Jan., 1880.
PATTON, JOSEPH R.	General Contractor, 4737 Maripoe Ave., Pittsburg, Pa.	Jan. 1899.
PATTERSON, F. W.,	Civil Engineer, Rm. 29, Court House, Pittsburg, Pa.	May, 1894.
PATTERSON, PETER,	Supt. National Tube Works, McKeesport, Pa.	Feb., 1881.
PATTERSON, P. C.,	Consulting Engineer, National Tube Works, McKeesport, Pa., 569 Versailles Ave., McKeesport, Pa.	March, 1892.
PECK, G. L.,	Supt. Pittsburg Division P. C., C. & St. L. Ry., Rm. 10 Union Station, P. R. R., Pittsburg, Pa.	Oct., 1896.
PETERS, SAMUEL,	Asst. to President, Pittsburg Reduction Co., New Kensington, Pa.	Dec., 1898.
PHILLIPS, F. C.,	Prof. Chemistry, Western University of Pennsylvania, Allegheny, Pa.	Jan., 1880.
PHILLIPS, JNO. M.,	Manufacturer, Manager of Phillips Mine Supply Co., South 23d and Mary Sts., Pittsburg, Pa.	March, 1898.
PHILLIPS, WILLIAM B.,	Editor, American Manufacturer and Iron World. 59 Ninth St., Pittsburg, Pa.	Jan., 1899.
PHIPPS, LAWRENCE C.,	Second Vice President and Treasurer, The Carnegie Steel Co., Ltd., Carnegie Bldg., Pittsburg, Pa.	Dec., 1898.
PORTER, J. E.,	Sec. and Treas. Carroll-Porter Boiler and Tank Co., 201 Penn Ave., Pittsburg, Pa.	May, 1887.
PRATHER, HENRY B.,	Manager, The American Stoke Co., 1202 Carnegie Bldg., Pittsburg, Pa. 535 Euclid Ave., Cleveland, Ohio.	March, 1899.
PRENTICE, W. J.	Mngr. National Cemept Co., Ltd., Pres. Pittsburg Mineral Screen Co., Director Royal Tennessee Marble Co. 1009 Liberty St., Pittsburg, Pa.	Jan., 1893.
PRICE, CHAS. B.,	Acting General Supt., Allegheny Valley R. R., 11th and Pike Sts., Pittsburg, Pa.	Feb., 1899.
PURVES, JAS.,	P. O. Box 375, Sharpsburg, Pa.	Dec., 1888.

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Name.	Occupation and Address.	Date of Election.
RAINEY, CHARLES T.,	Mining Engineer and Map Publisher, 938 Westminster St., N. W., Washington, D. C.	Jan., 1896.
REED, HUGH A.,	Member of firm of U. Baird Machinery Co., 123-125 Water St., Pittsburg, 167 Robinson St., Allegheny, Pa.	June, 1893.
REES, T. M.,	Vice Pres. and Gen. Mgr. J. Rees & Sons, P. O. Box 709, Pittsburg, Pa.	Jan., 1880.
REINHOLDT, K. O. P.,	1412 Carnegie Bldg., Pittsburg, Pa.	
RENKIN, WILLIAM O.,	5 Fulton St., Allegheny, Pa.	
RENO, G. E.,	Reno & Johns, Insurance Agents, 306 Fourth Ave., Pittsburg, Pa.	May, 1883.
RHODES, JOSHUA,	Penn'a Tube Works, Pittsburg, Pa.	Jan., 1880.
RICHARDSON, R. R.,	Duquesne Steel Works, of Carnegie Steel Co., Duquesne, Pa.	
RICKETSON, J. H.,	A. Garrison Foundry Co., 10 Wood St., Pittsburg, Pa.	Jan., 1880.
RIDDLE, WALTHER,	287 Ridge Ave., Allegheny, Pa.	Jan., 1892.
RIDINGER, CHARLES W.,	Electrical Engineer (Fessenden & Ridinger, 410 Penn Ave., Pittsburg, Pa.,) 3204 Perrysville Ave., Allegheny, Pa.	Oct., 1896.
RIGHTS, LEWIS D.,	Berlin Iron Bridge Co., East Berlin, Conn.	March, 1898.
ROBBINS F. L.,	Coal Operator, Pres. Pittsburg, Fairport & Northwestern Dock Co., Pres. Robbins Coal Mining Co., etc., 232 Fifth Ave., Pittsburg, Pa.	Jan., 1888.
Roberts, T. P.	Engineer, 361 Craig St., Pittsburg, Pa.	Jan., 1880.
RODD, THOS.,	Chief Engineer Penn'a Co., Tenth St. and Penn Ave., Pittsburg, Pa.	Jan., 1880.
ROGERS, CHARLES O.,	Hydraulic Engineer, with Chas. J. Jager Co., Boston, Mass.	April, 1897.
ROUSSEAU, H. H.,	Civil Engineer, Bur'u. Yards and Docks, Navy Dep't., Washington, D. C.	Nov., 1892.
ROWLAND, R. A.,	Manager Cement Dept. of Chas. E. Pope & Co., 421 Wood St., Pittsburg, Pa., 5534 Hay St., East End, Pittsburg, Pa.	March, 1896.
RUHE, C. H. W.,	Book-Keeper, 1423 Bluff St., Pittsburg, Pa.	Nov., 1889.

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
RUTHERFORD, BRABAZON,	Electrical Engineer for Allegheny County Light Co., Pittsburg, Pa. 4 Highland Place, Pittsburg, Pa.	Nov., 1897.
RUUD, EDWIN,	Fuel Gas & Mfg. Co., East Pittsburg, Pa.	Jan., 1888.
SAGE, RALPH V.,	Engineer, The Carnegie Steel Co., Ltd., Keystone Bridge Works, Pittsburg, Pa. 126 Graham St., Pittsburg, Pa.	Jan., 1899.
SCAIFE, O. P.,	C. F. Scaife & Co., Ltd., 421 Wood St., Pittsburg, Pa.	April, 1884.
<i>Scaife, W. Lucien,</i>	Chairman Scaife Foundry & Machine Co., 28th and Smallman Sts., Pittsburg, Pa.	March, 1883.
SCAIFE, W. M.,	Scaife Foundry & Machine Co., 336 Ridge Ave., Allegheny, Pa.	Sept., 1887.
SCHADE, CHARLES G.,	Engineer, P. O. Box 631, Canonsburg, Pa.	Sept., 1892.
SCHADE, GEORGE C.,	Chief Clerk Keystone Bridge Works, Dept. of Carnegie Steel Co., Ltd., Pittsburg, Pa. 296 Main St., Pittsburg, Pa.	March, 1897.
SCELLENBERG, F. Z.,	Consulting Engineer, 5746 Howe St., E. E., Pittsburg, Pa.	Feb., 1882.
SCHLIEPER, J. E.	Mechanical Engineer and Manager, Pittsburg Feed Water Heater Co., 1216 Carnegie Bldg., Pittsburg, Pa.	March, 1899.
SCHLUEDERBERG, GEO. W.,	Coal Operator and Manager of Mines, Oak Ridge Coal Co., Ltd., First Pool, Monongahela Gas Coal Co., 4203 Fifth Ave., Pittsburg, Pa.	March, 1892.
SCHMID, ALBERT,	Westinghouse Electric & Manufacturing Co., East Pittsburg, Pa.	Feb., 1885.
SCHOYER, A. M.,	Superintendent of Telegraph, Penn'a Lines West of Pittsburg, 43 Sherman Ave., Allegheny, Pa.	Feb., 1894.
SCHULTZ, O. G.,	Secy. and Treas. of Schultz Bridge Iron Co., Box 65, McKees Rocks, Pa.	Nov., 1885.
SCHWAB, J. E.,	General Supt. Duquesne Steel Works and Blast Furnaces of The Carnegie Steel Co., Ltd., Duquesne Steel Works, Duquesne, Pa.	March, 1899.
SCHWARTZ, F. H.,	Bureau of Engineers and Surveyors, Dept. Public Works, Pittsburg, Pa. 247 Matilda St., Pittsburg, Pa.	Nov., 1891.
SCOTT, CHARLES F.,	Electrical Engineer, Westinghouse Electric & Manufacturing Co., East Pittsburg, Pa.	April, 1890.

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Name.	Occupation and Address.	Date of Election.
SCOTT, JAS.,	Supt. Lucy Furnace, Carnegie Steel Co., Ltd., Pittsburg, Pa.	Feb., 1892.
SEAMAN, J. S.,	Seaman Sleeth Co., 41st St. and A. V. R. R., Pittsburg, Pa.	Oct., 1898.
SEWALL, A. W.,	Secy. Mack Manufacturing Co., Secy. Penn'a Asphalt Paving Co., Rm. 1107, Nos. 36-37 Nassau St., New York, N. Y.	June, 1896.
SHAW, A. G.,	Civil Engineer, County Engineer's Office, Pittsburg, Pa.	Jan., 1889.
SHAW, H. C.,	Secy. Lewis Foundry & Machine Co., S. S., Pittsburg, Pa. Glenshaw, Pa.	May, 1894.
SHOOK, LEVI,	Shook-Anderson Manufacturing Co., First Ave. & Ferry St., Pittsburg, Pa.	May, 1883.
SINGER, G. H.,	Singer, Nimick & Co., Inc., 135 Water St., Pittsburg, Pa.	Sept., 1880.
SINGER, W. H.,	Pres. Singer, Nimick & Co., Singer, Nimick & Co., S. S., Pittsburg, Pa.	Sept., 1880.
SIVERTSEN, O.,	Chief Draughtsman of New Castle Engineering Works, New Castle, Pa.	March, 1892.
SKINNER, O. C.,	Chief Chemist Shoenberger Steel Co., Pittsburg, Pa.	Dec., 1896.
SLOCUM, F. S.,	Chemist American Iron Works, Jones & Laughlins, Ltd., S. S., Pittsburg, Pa. Tenth Ave. and Amity St., Homestead, Pa.	April, 1892.
SNYDER, ANTES,	Engineer Rights of Way, P. R. R. Blairsville, Indiana Co., Pa.	Feb., 1880.
SNYDER, W. E.,	Mechanical Engineer, with Shoenberger Steel Co., Pittsburg, Pa. 287 North Ave., Allegheny, Pa.	Feb., 1899.
SNYDER, C. H.,	Civil Engineer, with Milliken Bros., 39 Cortlandt St., New York.	Oct., 1892.
SNYDER, W. P.,	W. P. Snyder & Co., German National Bank Building, Pittsburg, Pa.	April, 1884.
SPEER, J. R.,	Manager Blast Furnaces, Schoenberger & Co., Pittsburg, Pa.	Dec., 1894.
STAFFORD, S. G.,	Chemist, 516 Market St., Pittsburg, Pa.	April, 1893.
STAHL, K. F.,	Supt. James Irwin & Co., 57th St. and A. V. R. R., Pittsburg, Pa.	April, 1892.
STEVENSON, W. S.,	Oil and Gas Operator, Fairmount, West Virginia.	Jan., 1886.

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
STEWART, J. H.,	Iron Broker for Humphreys, Stewart & Co., Rm. 712 Lewis Block, Pittsburg, Pa.	Oct., 1886.
STEWART, R. T.,	Prof. Mechanical Engineering, Western University of Pennsylvania. Allegheny, Pa.	Dec., 1894.
STILLWELL, L. B.,	Electrical Director of Niagara Falls Power Co., Cataract Construction Co., Niagara Falls Power Co., Niagara Falls, N. Y.	Jan., 1890.
STRUNZ, F. B.,	Manufacturing Chemist S. Strunz & Son. 706 Bingham St., Pittsburg, Pa.	Feb., 1895.
SUTTON, STANBURY,	Secy. of the Consolidated Lamp and Glass Co., Coraopolis, Pa. 220 Western Ave., Allegheny, Pa.	Dec., 1892.
STUPAKOFF, S. H.,	Supt. of the Union Switch and Signal Co., Swissvale, Pa. 545 Turrett St., E. E., Pittsburg, Pa.	Feb., 1891.
SWAN, ROBERT,	Vice Pres. the T. A. Gillespie Co., 81 North Ave., Allegheny, Pa.	Feb., 1883.
<i>Swensson, Emil,</i>	Gen. Supt. Keystone Bridge Works, Carnegie Steel Co., Ltd., Pittsburg, Pa. 5511 Hays St., E. E., Pittsburg, Pa.	April, 1887.
TAYLOR, B. H.,	Civil Engineer, with Carnegie Steel Co., Ltd., Edgar Thomson Steel Works, Braddock, Pa.	Feb., 1884.
<i>Taylor, E. B.,</i>	Gen. Supt. of Transportation, Penna. Lines West of Pittsburg, 1003 Penn Ave., Pittsburg, Pa.	April, 1880.
TAYLOR, SAM'L A.,	Civil and Mining Engineer, Rms. 82-83 Schmidt Bldg., Pittsburg, Pa.	Jan., 1898.
TAYLOR, SELWYN M.,	Civil and Mining Engineer, 347 Fifth Ave., Pittsburg, Pa.	Jan., 1892.
TEMPLE, W. C.,	Consulting Mechanical and Electrical Engineer, Rm. 604, 541 Wood St., Pittsburg, Pa.	Dec., 1890.
TENER, G. E.,	Mgr. Pittsburg, Fairport, Northwestern Dock Co., Rm. 56, 232 Fifth Ave., Pittsburg, Pa.	May, 1886.
THOMAS, PERCY H.,	Electrical Engineer, Engineer's Dept. of Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., 4608 Forbes St., Pittsburg, Pa.	April, 1898.
THORSELL, J. A.,	Architect, Box 728, Pittsburg, Pa.	April, 1889.
TODD, JAMES,	Chemist and Engineer, Pres. The Sterling Varnish Co., 325 Water St., Pittsburg, Pa.	April, 1897.
TONE, S. L.,	Chief Engineer The Second Avenue Traction Co., The Pittsburg and West End Traction Co., Monongahela City Electric Ry. Co., Rm. 66, 326 Fourth Ave., Pittsburg, Pa.	March, 1891.

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Name.	Occupation and Address.	Date of Election.
TONNELE, THEO.,	Chemist, P. O. Box 222, McKeesport, Pa.	Dec., 1890.
TOWNSEND, C. W.,	Mechanical Engineer, Mgr. for Westinghouse, Church, Kerr & Co., 463 Ashland Place, Buffalo, N. Y.	March, 1892.
TRIMBLE, ROBT.,	Asst. Engineer Penna. Co., 10th St. and Penn Ave., Pittsburg, Pa.	Jan., 1880.
TURNER, C. A. P.,	Gillette-Herzog Mfg. Co., Minneapolis, Minn.	Sept., 1893.
TURNER, LOREN H.,	Supt. of Motive Power and Equipment, Pittsburg & Lake Erie R. R., Pittsburg, Pa., 61 Maple Terrace, Pittsburg, Pa.	March, 1899.
UNGER, J. S.,	Supt. of Armor Dept. Carnegie Steel Co., Ltd., Munhall, Pa.	Feb , 1896.
URQUHART, G. C.,	Asst. Engr., Chief Engr. Dept., P., C., C. & St. L. Ry. Co., Rm. 609, Penna. Lines, 10th St. and Penn Ave., Pittsburg, Pa.	May, 1893.
VANDERSLICE, JOHN,	Shop Supt. Keystone Bridge Works Dept. Carnegie Steel Co., Ltd., 5434 Broad St., Pittsburg, Pa.	March, 1897.
VANDIVORT, THEO.,	Civil Engineer, Asst. Engineer Rights of Way, P. R. R., Blairsville, Indiana Co., Pa.	Feb., 1892.
VERNER. M. S.,	Civil Engineer, Oakmont, Pa.	May, 1885.
VIERHELLER, PH.,	25 Plymouth St., Duquesne Heights, Pittsburg, Pa.	Dec., 1892.
WAGNER, KARL VON	Civil Engineer, Bridge Building, McKees Rocks, Pa.	April, 1893.
WALKER, J. W.,	Pres. and Gen. Mgr. Shiffler Bridge Co., 240 44th St., Pittsburg, Pa.	Jan., 1880.
WALKER, R. L.,	Mechanical Engineer, No. 50 Library Place, Allegheny, Pa.	Dec., 1891.
WARDEN, C. F.,	Civil Engineer, 7 Shetland Ave., Pittsburg, Pa.	Jan., 1883.
WELDIN, LEWIS C.,	Civil Engineer, Assist. Engineer P. R. R., Rm. 7, Union Station, P. R. R., Pittsburg, Pa.	May, 1894.
WENDT, E. F.,	Asst. Engineer P. & L. E. R. R. Co., 717 Third Ave., New Brighton, Beaver Co., Pa.,	April, 1892.
WHITE, F. L.,	Chief Draughtsman for Lucy Furnaces, Carnegie Steel Co., Ltd., 4616 Plummer St., Pittsburg, Pa.	May, 1892.
WHITE, T. S.,	Vice-Pres. and Chief Engineer of Penn Bridge Co., Beaver Falls, Pa.	May, 1883.

LIST OF MEMBERS.

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Name.	Occupation and Address.	Date of Election.
WHITED, WILLIS,	Engineer, The Keystone Bridge Works of The Carnegie Steel Co., Ltd., Pittsburg, Pa., 286 Main St., Pittsburg, Pa.	Jan., 1899.
WHITMAN, PAUL S.,	Brown Hoisting and Conveying Machine Co., Cleveland, Ohio.	Nov., 1897.
WHYTE, LAWRENCE R.,	Manager, Pittsburg Office of Frick Company, Waynesboro, Pa., 51 Schmidt Bldg., Pittsburg, Pa.	May, 1899.
WILCOX, FRANK,	Mechanical Engineer, with The T. A. Gillespie Co., Rm. 31 Westinghouse Building, Pittsburg, Pa.	Jan., 1894.
WILKINS, A. D.,	Chemist, Locomotive Works, 8 Sprague St., Bellevue, Pa.	Feb., 1893.
Wilkins, W. G.,	Civil Engineer, Wilkins & Davison, 91 Westinghouse Building, Pittsburg, Pa.	May, 1887.
WILLIAMS, J. E.,	P. O. Box 1120, Carnegie, Pa.	April, 1892.
WILLIAMS, F. H.,	Chemist for Riverside Iron Works, Wheeling, West Virginia.	April, 1892.
WILSON, F. T.,	Jersey Shore, Lycoming Co., Pa.	Jan., 1888.
WILSON, H. M.,	Sec. Taylor, Wilson & Co., Ltd., Founders and Machinists, No. 1 Grant Ave., Allegheny, Pa.	Jan., 1886.
WILSON, JOSEPH M.,	Asst. Armour-Plate Inspector U. S. Government, Eagle Hotel, Bethlehem, Pa.	April, 1892.
WILSON, NELSON C.,	Engineer & Contractor, Wilson & Wilson, 1012 Carnegie Building, Pittsburg, Pa.	March, 1898.
WILSON, W. A.,	Civil & Mining Engineer, Greensburg, Pa.	June, 1896.
WINSLOW, G. H.,	Consulting Electrical Engineer, Rms. 82-83 Schmidt Bldg., Pittsburg, Pa.	March, 1896.
WOLF, T. FRANK,	Civil Engineer for Penn Gas Coal Co., Irwin, Westmoreland Co., Pa.	Nov., 1894.
WOOD, E. F.,	Asst. Supt. Homestead Steel Works, Carnegie Steel Co., Ltd., Munhall, Pa.	April, 1892.
WOOD, RICHARD G.,	W. Dewees Wood Co., McKeesport, Pa., 243 Ridge Ave., Allegheny, Pa.	Sept., 1880.
WOODS, L. G.,	Rm. 506 McK. & Victory Building, 413 Fourth Ave., Pittsburg, Pa.	Jan., 1888.

RECAPITULATION.

AUGUST 1, 1899.

Honorary Members,	- - - - -	2
Members,	- - - - -	388
Total,	- - - - -	3

DECEASED MEMBERS.

YEAR ENDING JULY, 1899.

Name.	Elected.	Deceased.
DOXRUND, PETER.	Nov., 1890,	Feb. 10, 1899.
<i>Hunt, Alfred E.,</i>	Oct., 1881,	April 26, 1899.
MOORE, JAS. R.,	May, 1897.	Sept. 20, 1898.
OPSION, O. C.,	March, 1892,	July —, 1899.

EXCHANGES.

- ACADEMY OF NATURAL SCIENCES, PROCEEDINGS OF THE, Philadelphia, Pa.
 AMERICAN CHEMICAL SOCIETY, JOURNAL OF, Easton, Pa.
 AMERICAN ELECTRICIAN, Havemeyer Bldg., N. Y.
 AMERICAN ENGINEER, CAR BUILDER AND R. R. JOURNAL, Morse Building, New York.
 AMERICAN INSTITUTE ELECTRICAL ENGINEERS, TRANSACTIONS OF THE
 1009 Havemeyer Bldg., 26 Cortlandt St., N. Y.
 AMERICAN INSTITUTE OF MINING ENGINEERS, TRANSACTIONS OF THE
 99 John St., New York.
 AMERICAN JOURNAL OF RAILWAY APPLIANCES, 411-413 Pearl St., New York.
 AMERICAN MANUFACTURER AND IRON WORLD, Pittsburg, Pa.
 AMERICAN SOCIETY OF CIVIL ENGINEERS, TRANSACTIONS OF THE,
 220 W. 57th St., New York.
 AMERICAN SOCIETY OF MECHANICAL ENGINEERS, TRANSACTIONS OF THE,
 12 West 31st St., New York.
 ANALYST, THE, 59 Friends Road, Croyden, England.
 ANNALS DE L'ASSOCIATION DES INGENIEURS SORTIS DES ECOLES SPECIALES, DE
 GAND, Boulevard Friere-Orlan, 6. Argentina, Gand (Belgium).
 ANALES DE LA SOCIEDAD CIENTIFICA, Buenos Ayres.
 ANTHRACITE COAL OPERATORS ASS'N, 26 Cortlandt St., N. Y.
 ASSOCIATION DOS, ENGINEERS CIVIC PORTUS, Lisbon, Portugueseos.
 ASSOCIATION OF ENGINEERING SOCIETIFS, JOURNAL OF
 257 S. Fourth St., Philadelphia, Pa.
 ASSOCIATION OF PROVINCIAL LAND SURVEYORS, Toronto, Canada.
 BOSTON SOCIETY OF CIVIL ENGINEERS, 715 Tremont Temple, Boston, Mass.
 BRICKBUILDER, THE, 85 Water Street, Boston, Mass.
 BUILDING, ENGINEERING AND MINING JOURNAL, Sun Bldg, Queen St., Melbourne.
 CALIFORNIA STATE MINING BUREAU, San Francisco, Cal.
 CANADIAN ELECTRICAL NEWS, Toronto, Canada.
 CANADIAN SOCIETY OF CIVIL ENGINEERS, TRANSACTIONS OF THE
 112 Mansfield St., Montreal, Canada.
 CASSIER'S MAGAZINE, World Bldg, New York.
 CHEMICAL NEWS, THE, 6-7 Creed Lane, Boy Court, Ludgate Hill, London, Eng.
 CIVIL ENGINEERS' CLUB OF CLEVELAND, THE, Cleveland, Ohio.
 CLUB DE ENGENHARIA, Rio Janeiro, Brazil, S. A.
 COLORADO SCIENTIFIC SOCIETY, THE, Denver, Colorado.
 COMPRESSED AIR, 26 Cortlandt St., New York.
 CONN. ASSN. CIVIL ENGINEERS AND SURVEYORS, Birmingham, Conn.
 CORNELL UNIVERSITY, Ithica, New York.
 DEUTSCH AMERIKANISCHEN TECHNIKER-VERBANDES, Washington, D. C.
 ECOLE D' AP. DU GE. MARITIME, Paris, France.

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- ELECTRICAL ENGINEERING, 214 Monroe St., Chicago, Ill.
 ELECTRICAL REVIEW, 41 Park Row, Times Building, New York.
 ELECTRICAL WORLD AND ELECTRICAL ENGINEER, 253 Broadway, New York.
 ENGINEER, THE, 43 Cedar St., New York.
 ENGINEERING, 35-36 Bedford St., Strand, London, W. C.
 ENGINEERING AND MINING JOURNAL, THE, 253 Broadway, New York.
 ENGINEERING MAGAZINE, 120 Liberty St., New York.
 ENGINEERING MECHANICS, 430 Walnut St., Philadelphia, Pa.
 ENGINEERING REVIEW, London, England.
 E. INGENIERO CIVIL, 424 Corrientes, Buenos Ayres, Argentine Republic, S. A.
 ENGINEERING NEWS, Tribune Building, New York.
 ENGINEERING RECORD, THE, 277 Pearl St., New York.
 ENGINEERS' ASSN. OF THE SOUTH, Nashville, Tenn.
 ENGINEERS' CLUB OF PHILADELPHIA, PROCEEDINGS OF THE, 1112 Girard St., Philadelphia, Pa.
 ENGINEERS' CLUB, Kansas City, Mo.
 ENGINEERS' CLUB, Louisville, Ky.
 ENGINEERS' CLUB OF CINCINNATI, Cincinnati, Ohio.
 ENGINEERS' CLUB OF ST. LOUIS, THE, 1600 Lucas Place, St. Louis, Mo.
 ENGINEERS' SOCIETY OF WESTERN NEW YORK, Library Place, Buffalo, N. Y.
 FIELD COLUMBIAN MUSEUM, Chicago, Ill.
 FOUNDRY, THE, Detroit, Mich.
 FRANKLIN INSTITUTE, THE JOURNAL OF, 18 S. Seventh St., Philadelphia, Pa.
 GEOLOGICAL SURVEY OF PENN'A, Harrisburg, Pa.
 ILLINOIS STATE MUSEUM, BULLETIN OF THE, Springfield, Ill.
 ILLUSTRATED OFFICIAL JOURNAL (PATENTS), THE, London, W. C. Eng.
 INDIANA ENGINEERING SOCIETY, Cloverdale, Indiana.
 INDIANA SOC. OF CIVIL ENG. AND SURVEYORS, Remington, Ind.
 INDUSTRIAL UNIVERSITY, Fayetteville, Ark.
 INSTITUTION OF CIVIL ENGINEERS (excerpt Minutes of), PROCEEDINGS OF, 25 Great George St., Westminster, London, S. W.
 IOWA SOCIETY OF ENGINEERS AND SURVEYORS, Cedar Rapids, Iowa.
 IRON AGE, THE, 96-102 Reade St., New York.
 IRON & STEEL, 1190 Caxton Building, 334 Dearborn St., Chicago, Ill.
 IRON & COAL TRADES REVIEW, 222-225 Strand, London, W. C.
 IRON AND STEEL INSTITUTE, PROCEEDINGS OF, Victoria St., London, E. C.
 IRON TRADE REVIEW, Cleveland, Ohio.
 KANSAS UNIVERSITY QUARTERLY, THE, Lawrence, Kansas.
 LEHIGH UNIVERSITY, So. Bethlehem, Pa.
 LIVERPOOL ENGINEERING SOCIETY, Colquitt St., Liverpool, Eng.
 LOCOMOTIVE, THE, Hartford, Conn.
 MANUFACTURER'S RECORD, Baltimore, Md.
 MASSACHUSETTS HIGHWAY ASSOCIATION, JOURNAL OF, Boston, Mass.
 MASS. INST. OF TECHNOLOGY, Boston, Mass.
 MECHANICAL WORLD, New Bridge St., Manchester, England.

- MICH. COLLEGE OF MINES, Houghton, Mich.
 MICH. ENGINEERING SOCIETY, Climax, Mich.
 MINING BULLETIN, THE, Pennsylvania State College, State College, Pa.
 MODERN MACHINERY, Ashland Block, Chicago, Ill.
 MUNICIPAL ENGINEERING, Indianapolis, Ind.
 MUNICIPAL & RAILWAY RECORD, 141 E. 25th St., New York.
 OHIO SOC. OF SURVEYORS & CIVIL ENGINEERS, Columbus, Ohio.
 PHYSICAL REVIEW, THE, Ithaca, N. Y.
 POWER, Rms. 145-146 World Building, New York.
 PURDUE SOCIETY OF CIVIL ENGINEERS, PROCEEDINGS OF,
 Purdue University, Lafayette, Ind.
 RAILROAD GAZETTE, 32 Park Place, New York.
 RAILWAY AGE, THE, 1660-1664 Monadnock Block, Chicago, Ill.
 RAILWAY AND ENGINEERING REVIEW, 818 "The Rookery," Chicago, Ill.
 RENSSELEAR SOCIETY OF ENGINEERING, Troy, New York.
 REVISTA DE OBRAS PUBLICAS E MINAS, Lisbon, Portugal.
 ROADMASTER AND FOREMAN, 91-93 Jefferson St., Chicago, Ill.
 ROSE POLYTECHNIC INSTITUTE, Terre Haute, Ind.
 SCHOOL OF MINES QUARTERLY, COLUMBIA UNIVERSITY, 41 East 49th St., N. Y.
 SCIENTIFIC AMERICAN, 361 Broadway, New York.
 SMITHSONIAN INSTITUTION, Washington, D. C.
 SOCIETY OF ARTS, JOURNAL OF, John-street, Adelphi, London, W. C.
 SOCIETY OF CHEMICAL INDUSTRY,
 Palace Chambers, 9, Bridge St., Westminster, S. W., London.
 STATE ASSN. OF ENGINEERS, Norwich, Conn.
 STATE COLLEGE, State College, Pa.
 STATE GEOLOGIST, Springfield, Ill.
 STEVENS' INDICATOR, THE, Stevens' Institute of Technology, Hoboken, N. J.
 STREET RAILWAY REVIEW, 890 Old Colony Building, Chicago, Ill.
 SVENSKA TEKNOLOGFORNINGEN, Stockholm, Sweden.
 TECHNICAL SOCIETY OF THE PACIFIC COAST, THE,
 Room 56 Academy of Sciences, San Francisco, Cal.
 TECHNIC, THE ENGINEERS' SOCIETY OF THE UNIVERSITY OF MICHIGAN,
 Ann Arbor, Mich.
 TECHNIC CLUB, 228-230 S. Clark St., Chicago, Ill.
 TECHNOLOGY QUARTERLY, Mass. Institute of Techology, Boston, Mass.
 TEKNISKE, TIDSKRIFT, Stockholm, Sweden.
 THAYER SCHOOL OF CIVIL ENGINEERING, Hanover, N. H.
 TIN AND TERNE AND THE METAL WORLD,
 Room 705 Publication Bldg., Pittsburg, Pa.
 UNIVERSITY OF CALIFORNIA, Berkeley, Cal.
 UNIVERSITY OF ILLINOIS, Champaign, Ill.
 UNIVERSITY OF MINNESOTA, Minneapolis, Minn.
 UNIVERSITY OF PENNSYLVANIA, Philadelphia, Pa.
 UNIVERSITY OF WISCONSIN, BULLETIN OF, Madison, Wis.
 UNITED STATES BUREAU OF EDUCATION, Washington, D. C.

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UNITED STATES DEPT. OF THE INTERIOR,	Washington, D. C.
UNITED STATES DEPT. OF AGRICULTURE,	Washington, D. C.
UNITED STATES GEOLOGICAL SURVEY,	Washington, D. C.
UNITED STATES PATENT OFFICE, THE OFFICIAL GAZETTE OF THE,	Washington, D. C.
UNITED STATES WAR DEPARTMENT,	Washington, D. C.
VANDERBILT UNIVERSITY,	Nashville, Tenn.
WESTERN ELECTRICIAN,	Chicago, Ill.
WESTERN RAILWAY CLUB,	"The Rookery," Chicago, Ill.
WESTERN SOCIETY OF ENGINEERS, JOURNAL OF THE,	1737-9 Monadnock Block, Chicago, Ill.
YALE SCIENTIFIC MONTHLY, THE,	New Haven, Conn.

JOURNALS SUBSCRIBED FOR.

AMERICAN CHEMICAL JOURNAL,	Baltimore, Md.
CHEMIKER ZEITUNG,	Berlin, Germany.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA,

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

THE one hundred and ninety-seventh regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the Society's House, 410 Penn Avenue, Pittsburg, Pa., Tuesday evening, September 20, 1899, twenty-six members and visitors being present.

The meeting was called to order at 8.30 o'clock by the President, Mr. Harry J. Lewis.

The minutes of the previous meeting were read and approved.

For the Board of Directors, the following applicants were reported as passed and to be voted for at the next regular meeting :

EDWIN E. ARNOLD,	- -	Mechanical Engineer, with Westinghouse Machine Co., East Pittsburg, Pa.
LAWRENCE L. ARNOLD,	-	Chemist to Jones & Laughlins, Ltd., Pittsburg, Pa.
E. W. HESS,	- - - -	Engineer, with Engineering Dept. Penna. Lines West of Pittsburg, No. 707 Pitt Street, Wilksburg, Pa.
CYRUS ROBINSON,	- - -	Engineer, Corliss Engine Dept., Westinghouse Machine Co., East Pittsburg, Pa., P. O. Box No. 171 Edgewood Park, Pa.
ROBERT S. ORR,	- - -	Professor, Principal Ninth Ward School, Allegheny, Pa., Cass Avenue, Allegheny, Pa.
EDMUND YARDLEY,	- -	Statistician, Penna. Lines West of Pittsburg, Pa., cor. Tenth Street and Penn Avenue, burg, Pa.

The following gentlemen were balloted for and duly elected to membership:

- HARRY D. BAYNE, - - - Manager,
Pittsburg Office H. W. Johns Co., Tele-
phone Building, Pittsburg, Pa.
- LEVEN J. GRAY, - - - Manager,
Pittsburg Office of Miller, Wagoner,
Fieser & Co., Columbus, Ohio, 505
Hamilton Building, Pittsburg, Pa.
- CHARLES H. RICH, - - - Chemist,
Aliquippa Steel Co., Aliquippa, Pa.

MR. ASHWORTH—Mr. President, I think that the reading of the minutes shows that the report of the Smoke Committee was held over by motion until the September meeting. Is that not right?

Mr. Lewis reads from the minutes regarding the motion.

MR. DAVISON—I think there has been some mistake made about the printing of this report. It was the intention of the last meeting that this report was to have been printed for the purpose of discussion, and I do not think it should have been printed in the transactions until after it had been discussed. I think it should have been printed entirely independent of the transactions. Then, again, the members of this committee should have appeared in the printed report.

MR. WILKINS—I agree with Mr. Davison in thinking that the report should not have been printed in the transactions until it had been discussed by the Society. There are many slips of the pen that should have been corrected before it was printed in the transactions as a report of this Society.

MR. ASHWORTH—I think the reading of that report would be entirely in order.

The report of the Committee on Smoke Prevention was then read.

MR. LEWIS—There seems to be a good deal of mix-up in this thing. As I understood the last meeting, this report was to be printed in a separate way, and it is now in the minutes;

and the Assistant Secretary explains that the names of the committee, when it was sent out to the printer, were appended to the report, but that this was omitted by the printer, who also lost the MS. of some matter sent in by Mr. Schellenberg.

MR. GOW—The printed matter is before the Society, and some action should be taken. I move that the Society proceed to the discussion of the report as printed in the proceedings.

It was moved and seconded that the report be under discussion. (Motion carried.)

MR. ASHWORTH—Mr. Chairman, this is certainly a strange proceeding. We all understand that thoroughly. We have a report of a committee without any signature at all, and we do not know whether the majority endorsed this report or not, and furthermore, it has come before the public prematurely. There are members of this Society who have no knowledge of this except by hearsay. It is not right. Touching the matter of the report as regards the power of boilers there is nothing new under the sun in this report. There is a vast amount of ignorance in the handling of some boilers in the city. The amount of square feet per horse power is governed by tubular and water tube boilers, and every novice knows that. I must say that this is a very crude affair, and don't wonder that there are no names attached to it. But it is certainly formally drafted in our report. I had the Smoke Inspector of this city call upon me last Saturday and asked me if I had read this report, and I said, no. He asked me if I had read the article in the *Sunday Post*, and I said, no. He went out and got me a copy of it, and after reading that over I told him I had never seen it and never heard of it. Now, whether I am to be a second Dreyfus, accused of writing a secret bordereau, I do not know, but I was accused of being the author of that paper. I knew nothing about it, but I can endorse nine-tenths of it, and for the information of the members here I cut that out, and with your permission I will read it.

(Reads from newspaper article.)

Are we to have this report go to the public, inviting the satire of newspaper wits before it becomes the property of this Society? I regret exceedingly that this was published in our proceedings.

MR. CROOKER—Who is supposed to have written that report? As no names are to be seen on it, we do not know who is responsible. Whose names should appear?

MR. RIDINGER—John A. Brashear,
Charles Hyde,
Charles Fitzgerald,
James Scott,
R. A. Fessenden.

MR. ASHWORTH—The point that comes up now is, has the Society in its possession the original of the report before it went into the hands of the committee? Where is the original paper?

MR. RIDINGER—The printer has it now. After things are printed we do not keep the regular manuscript, if the proof is found to be correct according to the manuscript.

MR. DAVISON—It is my recollection that the names of the full committee were not on that report. I think there were about three names. If our printer has made the error, such as Mr. Ridinger explains, would he not be responsible for at least so much of the reproduction of this issue as would make the report complete?

MR. RIDINGER—I had some trouble of the same kind about the notice of the death of Captain Hunt, as the manuscript did not have on it the names of the committee.

MR. DAVISON—As far as newspaper criticisms are concerned, it is very evident, of course, there might be some truths in them. I might recall, however, that other reports of this Society have been assailed by the press; but I suppose that the good people of Pittsburg to-day voted for two and one-half million dollars that will be utilized for the purification of our

water supply, and that I think is partly due to one of the reports of a committee of this Society, which at one time was very severely handled by some of the newspapers of this city.

MR. CROOKER—Ever since this talk of this committee began there has been no end of trouble about it, and it seems that a report has come out which this Society should not endorse; therefore, I move that the report be recommitted for revision.

It was moved and seconded that the report as it stands be returned to the committee for revision.

MR. BOLE—It seems to me that we need some proper ruling in regard to the publishing of all such articles. This is not the only report which has been printed in this way. The report of the Power Committee was printed in this same issue. I think that the secretary of the Society is getting a little injustice tonight, as there are no established rules for his guidance in these matters. As it stands, this was a report to the Society to be either received or sent back to the committee for revision. There has been no well-formed plan of procedure given the secretary governing such cases. I would like to put in this word in defense of the secretary.

MR. WILKINS—This may be a little off the line of discussion, but it seems to me that we should bring it up, and that is the question of a new constitution. I think the Engineers' Society should have a Committee on Publication, and it seems to me in the new constitution, we should provide for a Committee on Publication, who should have authority to decide what shall and what shall not be printed. It certainly would relieve the secretary from a responsibility which I think he would be glad to be relieved of.

MR. CROOKER—My particular reason for making this motion is that there is a great deal in that report which is really wrong.

MR. ALBREE—Although that may officially right us, practically we have, as I understand it, sent it to all the different

exchanges. Now we can get up in school afterward and say that we did not do it. I think the best thing to do is to shut up and say nothing about it. It puts us in a very school-boyish sort of a position, and it would be better as far as the public is concerned, to say nothing.

MR. LEWIS—I believe it would be well to confine the discussion to the motion before the house and bring the other up in a separate motion.

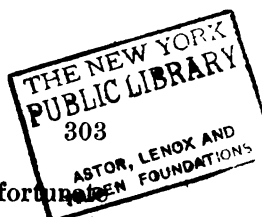
MR. ASHWORTH—I fully agree with what Mr. Albree has said ; if we can only learn to-night not to repeat this premature action by sending out our reports before we have heard anything of them ourselves. I cannot readily understand how the paper can be printed in advance as a report until it had been adopted by this Society. We have never endorsed it ; we are discussing it now after it has gone before the public.

MR. WILKINS—I agree fully with Mr. Albree and Mr. Ashworth, and I think the best thing to do is to accept the report and file it and say nothing more about it. The more we discuss it, the more we draw attention to it.

MR. SWENSSON—Mr. President, I was, in the beginning, of the opinion that we should suppress this issue, but I have changed my views. Do not suppress this one, but I think that we ought to refer the report back to the committee for revision ; show them what we think of it, and if they then think it worth while, they can take it up.

MR. ALBREE—In reading the minutes, as I remember the last meeting, the Society certainly ordered that the report be printed. Now that brings it down to the question, as far as the secretary is concerned, whether he would follow our usual custom of getting out something special. What I mean is, that Prof. Fessenden did not go out of his way in doing this, and I think, though we may not agree with the report at all, we do not want to be too severe on him.

MR. LEWIS—I think what has been done by the secretary



was done with the best of intention. It is a little unfortunate that it has come as it has, but remember that the secretary is a very hard worked man.

MR. FISHER—The most unfortunate part is that the names are not seen appended to it?

MR. SWENSSON—I would suggest that in the next issue that correction be made as regards the names left off in that report.

MR. CROOKER—I think that in view of all this discussion that people will be a little careful about putting their names on reports hereafter.

MR. FISHER—I would say that at one of the meetings I was to read the report of the Power Committee. The Society authorized the secretary to have it published, and it was impressed very strongly on my mind. I think the secretary was authorized by the Society, probably in discussion, to publish this report of the Power Committee without being read.

MR. ASHWORTH—We have it in all the technical journals.

[Communicated after adjournment by MR. REGINALD A. FESSENDEN—It must be regarded as an extremely unfortunate thing that the Society does not possess a copy of the rules and regulations which are supposed to govern the proceedings of the Society. Much time is thus wasted, and visiting members are apt to form wrong impressions. The present discussion is a deplorable instance of this. Aside from the fact that it is hardly considered quite the proper thing to do to discuss, especially in an unfriendly spirit, the communication of a committee when none of its members are present, and aside from the fact that the whole discussion was out of order in the absence of the committee and of any specified time for its discussion; practically the entire discussion turned upon a point which should never have arisen, *i. e.*, the printing of the report.

It is almost incredible that it should not have been realized that the publication of the report was not only entirely proper,

but not a matter of option at all. In the first place, the minutes are supposed to contain a record of all important business transacted by the Society. Neither the secretary nor any other officer has the power to suppress any part of the minutes, without specific instruction to that effect, and would be liable to censure for so doing. In the second place, no officer has the power to incur bills for special printing, without vote of the Board of Direction. In the third place, the publication of reports submitted but not approved is established by universal precedent; not only of other societies, but also of our own Society. I would call attention, as an example, to the report of the Standardizing Committee, of the American Institute of Electrical Engineers, which was printed before approval in their proceedings of May, 1899, and was again printed, after considerable discussion, in a revised form, as approved by the Institute in their June proceedings. Many other instances might be given. Again, it is the precedent in our own Society, for in our proceedings for January, only eight months ago, p. 24, will be found the following :

“The report of the Power Committee . . . was held over . . . it being voted to have it read by title and printed in *the Proceedings of the Society*.”

It is, perhaps, unnecessary to say that the report of the Power Committee has not been approved, even at this date, and yet it was then printed in *the Proceedings* before being approved, *by the specific direction of the Society itself*. Surely, the officers of the Society have a right to expect that the members will have some regard for the precedent they themselves have made, even if they are not acquainted with the methods of other societies.

As regards the discussion itself, perhaps the less said the better. Aside from the fact that, as mentioned above, a certain amount of decency would seem to require that a discussion in such an unfriendly spirit should not take place in the entire absence of the members of the committee, or of any notification

to them that such discussion was to take place, in the absence of any time having been specified for the discussion, the committee might naturally have supposed, in accordance with precedent, that the initiative would have been left to them. Speaking for myself, I can heartily agree with Mr. Crooker's remark, "that people will be a little careful about putting their names on reports hereafter." I opine that this will hold true of any society where reports are run down in the absence of the committee, and such remarks made as that of Mr. Ashworth, "that he does not wonder that no names were signed to the report." Fortunately, the members of the committee are of sufficient standing not to be seriously disturbed by such remarks made in regard to a report they have unanimously approved.

It is worthy of note that the *only unfavorable criticism of the report*, with the exception of one anonymous communication in the *Post*, which the editor states was handed him by a man whom he is sure did not write it, has been on the part of our own members. And, moreover, some of these are evidently made under a misapprehension. Mr. Ashworth, for example, finds fault with it, because "there is nothing new under the sun in the report." Why a committee, appointed primarily with a view to establish a rating of boilers, should be expected to devote its time to original research is, as Dundreary would say, "one of those things no fellow can find out."

MR. ALBREE—In view of the unfortunate affair we are discussing, it seems that we should go on and discuss these reports to-night. I move that we discuss the report of the Power Committee.

Moved and seconded that the report of the Power Committee be taken up for discussion. (Motion carried.)

MR. ASHWORTH—This is the first time we have had this report. I think it would be well to have this held over to give them ample time to read up on it. I move it be laid over.

MR. CROOKER—I think it would be a good idea to appoint some regular time for it to be taken up again. It seems to me that this report ought to have a good deal of value in it.

MR. ASHWORTH—I would designate our next meeting.

MR. BOLE—It represents some hard work even if it is not worth anything, and as it was the intention to make this report take the place of the usual paper at this meeting, I think it would be worth while to have it read aloud. Otherwise very few of the members will ever read it.

Moved and seconded that the report of the Power Committee be read and discussed at the next meeting. (Motion carried.)

MR. FISHER—I would suggest that it be put on the notices.

MR. GOW—Another thing about this last issue of our proceedings that while it opened with this report of the Smoke Committee, it closed with what represents a great deal of hard work; and a full list of the members of this Society, well arranged, and the best list that yet has been made. I think that all the members of this Society were glad to see that thing done and so well done. I think it would be proper that the Society should express to the secretary in the form of a motion a vote of thanks for this excellent list of members.

It was moved and seconded that the vote of thanks be tendered to the secretary for the excellence of the membership list, and also of the publications in the last report. (Motion carried.)

MR. GOW—What is the matter with the Entertainment Committee that they did not take us up the river in the boat? Why didn't we go?

MR. DAVISON—I supposed that they did go. What I want to know is, why I was not invited?

On motion the Society adjourned at 9:50 P. M.

REGINALD A. FESSENDEN,

Secretary.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS

The one hundred and ninety-eighth regular meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the University of Pittsburgh, Avenue, Pittsburg, Pa., Tuesday evening, October 1st, 1910. Thirty-three members and visitors were present. The meeting was called to order at 8:30 o'clock by the President, J. Lewis.

The minutes of the previous meeting were read and approved.

For the Board of Direction the following report was reported as passed, and to be voted for at the next regular meeting:

FRANK A. ESTEP,	President and Treasurer. R. D. Small Co., 170 Grant Avenue, Allegheny, Pa.
G. C. SMITH,	Manager. Union Steel Casting Co., Pittsburg, Pa.
F. L. O. WADSWORTH,	Director Elect. Allegheny Observatory, Allegheny, Pa.
HENRY M. WILSON,	Chief Draughtsman, at Riter-Conley Manufacturing Co., Plate Dept., Pittsburg, Pa., Clanton Avenue, Allegheny, Pa.

The following gentlemen were balloted for and duly elected to membership:

EDWIN E. ARNOLD,	Mechanical Engineer, with Westinghouse Machine Co., Pittsburg, Pa.
LAWRENCE L. ARNOLD,	Chemist, to Jones & Laughlin, Ltd., Pittsburg, Pa.
E. W. HESS,	with Engineering Dept., Penna. Locomotive Works, West of Pittsburg, No. 707 Pitt-street, Wilkensburg, Pa.

- CYRUS ROBINSON, - - - Engineer,
Corliss Engine Dept., Westinghouse
Machine Co., East Pittsburg, Pa.; P. O.
Box No. 171, Edgewood Park, Pa.
- ROBERT S. ORR, - - - Principal
Ninth Ward School, Allegheny, Pa.;
Gass Avenue, Allegheny, Pa.
- EDMUND YARDLEY, - - - Statistician,
Penna. Lines West of Pittsburg, Pa.;
cor. Tenth Street and Penn Avenue,
Pittsburg, Pa.

MR. LEWIS—Is there any new business before the house?

PROF. FESSENDEN—I noticed that in the discussion at the last meeting it seemed to be the opinion that reports which had not been passed upon by the Society should not properly be published in the minutes. That opinion is not correct. In view, however, of the inconvenience sometimes caused by reports being prematurely published in the newspapers, I would move: "That all reports of committees of the Engineers' Society of Western Pennsylvania which have not been formally approved by the Society at their presentation, be published when, and in such manner as may then and there be decided upon by the Society, and with them a specific statement that the report has not been adopted by the Society. And otherwise not printed."

MR. LEWIS—The object is to not have any committee report appear in our regular printed proceedings until it has been sanctioned by the Society. (Motion carried.)

PROF. FESSENDEN—In the discussion of the Smoke Committee at the last meeting, the report was referred back for revision. Now in the minutes there appears no criticism of the matter of the report. I believe that there was some criticism of this, but for some reason it does not appear upon the minutes. If the committee is to revise it, it must know on what grounds the revision should be made. I would there-

fore move that the report be discussed on its merits so that the committee might have some way to know how it is to take action.

MR. BOLE—In line with the Professor's suggestion, I move that he read that report clause by clause, and after reading each clause ask for remarks by the members.

The motion was seconded and carried.

PROF. FESSENDEN—Before reading this report, I would like to make one remark.

As you may remember, during Mr. Swensson's presidential address he spoke of the fact that this Society should increase its influence in this city. The remark was approved by the Society, and some of us have been working along this line.

The city for the first time in the history of the Society, invited the Society to do certain work for it which could not be done by any *individual*. The matter was taken up and this committee appointed. The committee have done the work so far as they have been able. As a member of this committee, I would say that, since we have voted that the work should be taken up, the Society members as a whole should co-operate with the committee. It is probable that a number of the members of the committee would not undertake the thing again were it to be done over again, but we hope that the members of the Society will look at it in the light that since a public duty has been accepted that duty ought to be fulfilled, and we should not back down.

REPORT OF COMMITTEE ON SMOKE PREVENTION. ✓

"Your committee was requested by Mr. E. M. Bigelow, in a letter dated March 1, 1899, to furnish him with a rule for the rating of boilers, as this question was one of some importance in connection with the suppression of smoke in Pittsburg.

"Your committee has therefore collected all the data it could, and has been in correspondence with the principal manufacturers of boilers and stokers. It has also sought the advice

of engineers who have had experience in the matter. We would respectfully report as follows :

"In the rating of steam-producing plants the following things are to be taken into consideration.

"1. Amount of heating surface per H. P.

"2. Amount of grate surface per H. P.

"3. Amount of draught.

"As regards the first of these, your committee does not feel able, on the evidence furnished, to fix any settled amount of heating surface per H. P. For, whilst it is undoubtedly true that, in the majority of cases, the following rates will be found to be proper, *i. e.*, horizontal tubular, 12 sq. feet; water tube, 10 sq. feet, the boilers being in each case capable of being forced economically to between 50 and 60 per cent. above the rated capacity, yet in at least one case your committee has good evidence that water tube boilers, of one particular type, have been run continuously and economically for long periods with but $8\frac{1}{2}$ sq. feet per H. P. (By H. P. is meant rating, *i. e.*, either $34\frac{1}{2}$ lbs. of water from and at 212° F., or 30 lbs. of water from 100° F. to steam at 70 lbs. above atmospheric air.)"

MR. ASHWORTH—Is that not a typographical error? I think $34\frac{1}{2}$ should be $34\frac{1}{4}$.

MR. BOLE—I would like to ask the Professor why the expression "atmospheric air" is used.

PROF. FESSENDEN—I don't know how it came; originally it was atmospheric pressure, but it was changed by some one. We can take that point into consideration.

MR. ASHWORTH—It is very probable that it is an error. It is really not 70 pounds gauge pressure. That is how we sometimes err upon such points.

PROF. FESSENDEN—I remember that at the time that point was taken up, and it is possible that there was some error in it.

MR. BOLE—"Above atmosphere" would be the way to express it, I think.

MR. ASHWORTH—I would also say, that, in considering this, while I approve of this idea of 12 sq. feet, the majority of our text-books say, that we have been using for a great many years, 15 sq. feet. Can any one enlighten us as to why that should be 12 feet? I know that we are running so far above what is rated that 12 feet would be made a better factor.

MR. CROOKER—I would say that we used to take on horizontal tubular, 16 feet, and cylinder, 8 feet.

MR. BOLE—Well, the report of the committee would come about between those two.

“There is another reason why your committee does not consider it advisable to go into the matter, in addition to its difficulty, and that is that by making any hard and fast rule, a hindrance might be placed on possible improvements and progress, and manufacturers who might succeed in making the heating surface more efficient, might be placed at a disadvantage.

“Moreover, for the purpose required, such a rule is unnecessary, for the smoke is produced in the furnace, and it is evident that if we accomplish perfect combustion in the furnace it is a matter of indifference, so far as the smoke is concerned, what becomes of the heat, whether it is utilized in a boiler of 80 per cent. efficiency or in one of only ten. It is a matter which concerns only the owner of the plant, who has the right to run the plant as inefficiently as he chooses, and who, if he desires to obtain a knowledge of the best arrangement for efficiency in his case, can always obtain the services of an engineer experienced in such matters. It is, therefore, not a matter which concerns the general public at all, as it is not when a boiler is working inefficiently, but when it is producing smoke that it becomes a public nuisance.

“As regards the second of these matters, *i. e.*, the area of grate surface per H. P., your committee finds that with the draught mentioned in the following section, the following rates of combustion are to be recommended :

"1. Run of mine one-sixth to one-fifth sq. feet per H. P.

"2. Slack, bituminous or anthracite, one-fourth to one-fifth sq. feet per H. P. The air space in grate being taken as 50 per cent."

MR. CROOKER—I would like to ask what that means, one-sixth to one-fifth sq. feet per H. P.

MR. GOW—The rate of combustion, if it means anything, must mean the number of pounds per square foot per hour. I would like to ask what the committee meant. As it is at present, it means nothing to me.

PROF. FESSENDEN—It is easy to fall into error in such matters; Mr. Gow has fallen into one. His statement is incorrect. The rate of combustion does not mean the amount of coal per square foot per hour. It has nothing to do with the area of the grate. The rate of combustion means the pounds of coal per unit of time. From Mr. Gow's own mistake he will see how easy it is to fall into error with these terms. We hope that the criticism will remove these errors, however. The rate of combustion per square foot would *vary with* the number of square feet per H. P., but it *is* not the number of square feet per H. P. It only bears a relation to it.

MR. BOLE—Would it not be better put as the "proportion of grate area to the H. P.?"

PROF. FESSENDEN—"That with the draughts mentioned in the following section, the following proportions of grate area to the H. P. are to be recommended?"

MR. BOLE—That would tally with my suggestion.

"The above rates are for hand firing. For mechanical stoking your committee finds that the rates should be the same.

"As regards the third matter, *i. e.*, draught, we find that the draught should in all cases be measured, not in the stack or in the ash-pit, but in the furnace, over the fire, and with the furnace door closed and the ash-pit door open, when working the grate at the above mentioned rate."

PROF. FESSENDEN—Mr. Ashworth mentioned the fact that all boilers do not have furnace doors, which point is well taken.

“Measured at this place the draught, in the most unfavorable conditions, *i. e.*, in bad weather, should be :

“1. For run of mine, a minimum of three-eighths inch.

“2. For slack, a minimum of one-half inch.

This, also, should be the same for hand firing and for mechanical stokers.”

MR. ASHWORTH—I would suggest that the paragraph reading, “For run of mine, a minimum of three-eighths inch, and for slack, a minimum of one-half inch,” be changed. I would favor increasing that in justice to the boiler. I would suggest that we raise those figures slightly.

PROF. FESSENDEN—I think, Mr. Ashworth, in the proposed method of measurement the draught would show somewhat less than if measured in the usual place. When you had a larger draught should that draught be measured in the furnace, over the fire, with the furnace door closed and the ash-pit open; as we propose?

MR. ASHWORTH—It would be measured at the back connections.

“As regards the method of preventing smoke, your committee has reached the following conclusions :

“1. That whilst in an ordinary furnace smoke may be made very light by very careful hand firing, yet, in practice this cannot be obtained continuously, and that the use of special furnaces or appliances should be insisted on and made compulsory by law.”

MR. GOW—I don't believe that this Society should put itself on record as adopting this paragraph as its opinion, “While in an ordinary furnace smoke may be made very light by very careful hand firing, yet in practice this cannot be obtained continuously,” and second, “the use of special furnaces or appliances should be insisted on and made compulsory by law.” We should know what sort of special appliance is meant.

Nearly every average fireman thinks he could put some appliance on the boiler to do away with smoke. During the past ten years, I have run across hundreds of such devices. What special appliance? Whose and what make? There are a large number on the market. Some are very valuable in particular places; any special appliance might be very good in one place and bad in another. I would say that regarding that paragraph as a whole, I do not consider the first statement correct. I think the expression, "special furnace or appliance," is entirely too vague, and I would very much dislike to see steam users compelled to use some patented device.

PROF. FESSENDEN—By *special* is meant "out of the ordinary."

PROF. ASHWORTH—I would strike out the word *special*, and use the word *such*. There is danger in the word *special*. In the course of time there will be some appliances developed, and the manufacturers of this special furnace, in the modern parlance of the day, might get into such a position as to have a cinch. Make it *such*, which really covers the ground.

A VISITOR—Is it not possible to push a boiler beyond its capacity and still not make smoke if it is properly handled? I saw a lot of tests made in Cleveland about two years ago. There were some photographs taken of some of the plants at the smokiest times they could find. They had a lot of these pictures and some of the boilers that were crowded very hard hardly showing any smoke at all.

PROF. FESSENDEN—In reply to the statement made by Mr. Gow that he is able himself to fire a boiler successfully by hand and that therefore special appliances are not necessary, I would say that I have no doubt as to what Mr. Gow can do in the way of firing a boiler, for we all know that he is a man of great ability, but men of less ability, such as can be hired for the daily wages of a fireman, can not be depended upon to do the same kind of work. I think it must be granted

by every man who has had practice in engineering that any average man can learn to fire well. You can stand beside him and make him do it as long as your valuable time will permit you, but when you have left the place, you will find it making smoke. It seems to me that you will have to use a special appliance of some kind. I see no escape from it, and those are the two points we made. It seems to me we are absolutely driven to it, and we must use some special appliance. By special, we mean different from the common.

MR. N. C. WILSON—In regard to that word *special*, it has been my own experience that a common furnace stoker may be a successful one in one case and useless in another. That word special seems to apply as suitably to that particular furnace and that particular boiler, and I think under the circumstances it is a better word than any that have been suggested.

MR. SCHELLENBERG—Use the word *suitable* instead of *special*.

MR. GOW—I still insist that the last clause there which says, that the use of special furnaces or appliances should be insisted upon and made compulsory by law, should not be adopted by this Society. Let the law demand that the steam user stop his smoke. Let him decide what kind of an appliance he shall use. My particular objection to that paragraph is that we ask that a law be passed making it compulsory for steam users to adopt a certain appliance.

MR. CROOKER—I think the passage of such a law would be mischievous, unless we state what kind of an apparatus, and that would bring us into politics. I believe we can get rid of the smoke, but when we go on to say that anything in particular shall be used, it is a mistake.

MR. ENGSTROM—To be consistent, might it not be proper to say it makes no difference what kind of special appliance is to be used, so that the combustion is perfect?

"2. That the best method of preventing smoke is to burn the fuel in a separate chamber, so that the combustion is complete before the gases touch the surface of the boiler. If the gases are imperfectly burned, then, on coming into contact with the cooler water surface they deposit soot, and smoke is produced. If the combustion is perfect this does not occur.

"3. Where this method is not practical, as in boilers already set and where there is no room, the best results are obtained by mixing the smoke, as it passes from the furnace, with heated air, the effect of which plan increases as the temperature of the air increases, thus burning the smoke.

"4. That as, even with special furnaces of the above types, with hand firing, the combustion is irregular and hence some smoke must be produced at times, the use of mechanical stokers is strongly recommended, especially in all plants above 100 H. P."

MR. GOW—Paragraph 2 says that the best method of preventing smoke is to burn the fuel in a separate chamber, so that the combustion is complete before the gases touch the surface of the boiler. That, of course, is the opinion of this committee, and is the sum total of all the wisdom that they have been able to gather together on this subject. As a member of this Society, I have to say that I cannot vote in favor of the adoption of such a statement as the opinion of this Society. What kind of special appliances use the separate chamber? Why should we put ourselves on record as recommending a peculiar form of furnace? We can protest against smoke, but we have no business to recommend particular types of furnaces.

PROF. FESSENDEN—In reply to the question, "What kind of special appliances use the separate chamber?" I would say that there are many. It was one of this special kind which took the prize at the last international competition at Paris. We have two classes of devices, one in which smoke is not

produced at all, and the other in which it is produced and then burned afterwards. Now, the only furnaces which we have been able to find record of that do not produce smoke at all are those in which the fuel is burned in a separate brick chamber, and in which combustion is made complete and the flow of the burned gases then passes under the boiler. In the second class, the coal is burned and the gases rise up and afterward touch the comparatively cool surface of the boiler, are decomposed and smoke is formed which is burned in some other part of the furnace.

MR. ASHWORTH—I would suggest this, "A method very much desired is to burn the fuel in a separate chamber."

DR. STAHL—Why not say, "A good method is to burn the fuel in a separate chamber."

A MEMBER—Is the smoke made and then consumed or does it not make any smoke?

MR. LEWIS—it might be well for this report to include a definition of smoke.

"5. As mentioned above, there is a lower limit to grate area per H. P., below which the furnace is not heated enough to insure complete combustion, and smoke is thus produced. For this reason all plants should be subdivided into two units at least, in order that the boilers may never run at a lower activity than one-third of their rated H. P."

MR. GOW—I raise the same objection to that paragraph that I raised to No. 1. Why should we put ourselves on record as recommending and requesting legislation on this.

PROF. FESSENDEN—I am afraid that if we do not recommend anything, the result of the work of this committee will not be very great. This is simply a recommendation, and if any one can show that in hand firing, with its necessary opening of doors, the combustion can be made regular and not intermittent, we can cut out that part of it. If Mr. Gow can show us some plants in which hand firing is used where open doors do not affect combustion, we would be glad to cut that out.

MR. GOW—Now paragraph 4 recommends a mechanical stoker. There is not a mechanical stoker in the market which has a separate fuel chamber, still this paragraph recommends mechanical stokers.

PROF. FESSENDEN—We say here, that the best way to prevent smoke is to burn the fuel in a separate chamber; that it is an efficient method, and then added to that we say that we should use mechanical stokers.

MR. CROOKER—I think the objection to all these paragraphs is that when you boil them down it confines us to some particular stoker.

PROF. FESSENDEN—There are from 20 to 40 kinds of stokers, and when we recommend a stoker we do not give a lever to any particular company. There are so many stokers that I don't think that it could be taken as meaning that we recommended any particular one.

MR. ASHWORTH—It seems to me that there might be some error in the statement that in furnaces above 100 H. P. mechanical stokers should be used. There are stokers at the same time that are doing very poorly. We all agree on this point that a device that will produce excellent results in one place will be an utter failure in places under other environments and conditions and this will be found in many cases. As I have stated before, several other devices are being used where stokers cannot be applied. There is one case in which I know by experience that the stoker did not fill the bill and another device did, so that I think this rather an arbitrary idea to recommend stokers in plants above 100 H. P.

MR. BOLE—I think that paragraph might be left out because it involves closing down a boiler and furnace for 10, 15 or 40 minutes.

PROF. FESSENDEN—As a member of the committee I would like to thank the members for the criticisms they have given this report, for when three or four men get together they are very likely to omit about twenty things.

MR. GOW—It is ten o'clock and some of the members are leaving. I move that the discussion of the report of the Power Committee be postponed until next meeting and made the special order of the evening. (Motion seconded and carried.)

MR. LEWIS—I read the notice of the death of Samuel Peters, a member of this Society, injured at Jones & Laughlins, September 28th, and died September 29th.

It was moved and seconded that a committee be appointed to prepare a suitable memorial on the death of Samuel Peters. (Motion carried.)

The President then appointed Mr. Geo. H. Clapp, Mr. Ralph Crooker, Jr., and J. M. Bailey as this committee.

The Programme Committee made a report of progress.

On motion the Society adjourned at 10:10 P. M.

REGINALD A. FESSENDEN,

Secretary.



ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA,

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The one hundred and ninty-ninth regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the Society's House, 410 Penn Ave., Pittsburg, Pa., Tuesday evening, November 21, 1899; thirty-two members and visitors being present.

The meeting was called to order at 8:30 o'clock, the President, Mr. Harry J. Lewis being in the chair.

The minutes of the previous meeting were read and approved.

For the Board of Direction, the following applicants were reported as passed and to be voted upon at the next meeting:

F. HARDING BEEBE,	- -	Draughtsman, with Julian Kennedy, Pittsburg, Pa.; 5703 Rural Ave., Pittsburg, Pa.
FREDERICK McD. GODDARD,		Electrician, with George Westinghouse, Pittsburg, Pa.; 6356 Marchand St., Pittsburg, Pa.
DAVID P. JONES,	- - -	Consulting Mechanical Engineer. Room 7, Stevenson Building, Pittsburg, Pa.
WILLIAM B. MILLER,	- -	Draughtsman, with Julian Kennedy, Pittsburg, Pa.; 16 Niagara St., Pittsburg, Pa.
WALTER M. McLEAN,	- -	Master Mechanic, Works No. 3, Pittsburg Plate Glass Co., Ford City, Pa.
GUY D. NEWTON,	- - -	Draughtsman, with Julian Kennedy, Pittsburg, Pa.; 3317 Madison Ave., Pittsburg, Pa.
P. K. SLAYMAKER,	- -	Draughtsman, with Julian Kennedy, Pittsburg, Pa.; 1507 Federal St., Allegheny, Pa.

JOSHUA G. SPLANE, - - - Manager,
Pittsburg Department, of National
Transit Co., 323 Fourth Ave., Pitts-
burg, Pa.

The following gentlemen were balloted for and duly elected to membership:

FRANK A. ESTEP, - - - President and Treasurer,
R. D. Nuttall Co., 179 Grant Ave.,
Allegheny, Pa.

C. C. SMITH, - - - Manager,
Union Steel Casting Co., Pittsburg,
Pa.

F. L. O. WADSWORTH, - - Director-Elect,
Allegheny Observatory, Allegheny,
Pa.

HENRY M. WILSON, - - Chief Draughtsman,
Riter-Conley Manufacturing Co.,
Plate Department, Pittsburg, Pa.;
Clayton Ave., Allegheny, Pa.

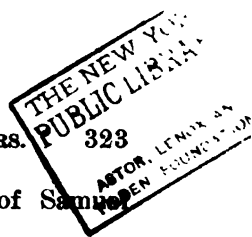
MR. LEWIS—Are there any committee reports? If not, I would say for the House Committee that they are now in negotiation for the extension of our lease of this property, which expires in 1901, and they hope this will be satisfactory to the members. They expect to secure a renewal of the lease for a term of five years, at about the same terms as at the present time.

It was voted that the nominating committee for officers to serve during the ensuing year, be appointed by the chair. The following members were appointed:—Messrs. Thomas H. Johnston, Charles Davis, Thomas P. Roberts.

It was voted that the Reception Committee be instructed that it was the sense of the meeting that they should arrange a smoker during the present year. (Motion carried.)

MR. JOHNSTON—I move that the attention of the Reception Committee be called to the fact that the time is approaching for our usual annual banquet, and would move that they begin to arrange with reference to it. (Motion seconded and carried.)

MEMORIAL ON DEATH OF MR. SAMUEL PETERS.



The report of the committee on the death of Samuel Peters was then read.

MEMORIAL ON DEATH OF MR. SAMUEL PETERS.

It is with regret that we have to announce to the Society the death of our fellow member, Mr. Samuel Peters, which occurred because of accident which befell him in the course of his professional duties, on Sept. 28th, '99.

Mr. Peters was born in Crewe, England, July 29th, 1847, and it may be said that he actually grew up in the shops of the London and North-Western Railway Co., where he spent some nine years, the last three being in the laboratory for which he was fitted in the excellent technical school known as the Crewe Mechanics' Institute, established by Mr. John Ramsbottom, and maintained by the London and North-Western Railway Co.

Mr. Peters came to the United States in 1869 to become chemist for the Bay State Iron Co. of Boston on the recommendation of his former superintendent, Mr. Ramsbottom, and remained there until 1878. During these years Mr. Peters did much valuable work in connection with the manufacture of open hearth steel and ferro-manganese and in the perfecting and shortening of laboratory methods, some of the methods devised by him being in general use at the present time. The difficulties which a chemist had to meet in those days when there were very few laboratories, no records and only long and tedious methods can be appreciated by the working chemists of to-day.

He next established the laboratory at the Burden Works at Troy, and in 1882 became superintendent of the Portland Rolling Mills, where he spent the next sixteen years of his life in hard and useful work.

He came to Pittsburg in 1898 at the instance of our late President, Capt. Alfred E. Hunt and remained with him and the Pittsburg Reduction Co. until the month of his death, entering

the employ of Jones & Laughlins, Ltd., only three days before the accident which took from the Society a most valuable member.

Mr. Peters was married at Crewe, England, 1872, and leaves a wife and two daughters, to whom the Society extends its sincere sympathy in their great bereavement.

GEO. H. CLAPP,

RALPH CROOKER, JR.

It was moved and seconded that the report be received and printed. (Motion carried.)

MR. LEWIS—Is there any further new business? If not, we are ready for the discussion of the report of the Power Committee, which is the special order of the evening.

It was moved that a synopsis of the report of the Power Committee be read instead of the entire report.

MR. BOLE—This committee was appointed about four years ago. It was so long ago that they have almost forgotten for what they were appointed. The object was to get at the actual cost of power in Pittsburg. They had a lot of circulars printed, and asked for information, and you will find a copy of that list of questions in the back part of the report. One of these is simply filled out just as it came back to the committee. The replies were very meager indeed; so much so that it was thought we had better emphasize the fact that there had been very little information forthcoming from our efforts.

(This report was printed in the June number of the Proceedings of the Society, pages 250 to 265.)

MR. LEWIS—Is there any discussion of the report?

MR. W. B. FLINT—I notice on page 261, it speaks of 3.3 pounds per annum. Does that mean per hour?

MR. BOLE—Yes, that means the annual average of an hour's consumption.

MR. SNYDER—I would like to ask for an explanation of the expression "steam accumulators"; I don't understand that.

MR. BOLE—There is such a thing as a steam accumulator which serves the same purpose as hydraulic. The expression *etc.* was supposed to cover almost anything else which can use steam, except steam engines.

MR. JOHNSTON—I have nothing to say in particular as a discussion of the subject which the report presents; but I would like to say that it is a matter of regret, that proprietors of steam engines have not seen fit to supply us with the information asked for by the committee. Not a great while ago, I was asked to find out for certain parties, as nearly as possible, the aggregate amount of horse power of engines and boilers in use in and about the city of Pittsburg. My first dash for information was at the work of this committee. I found that the proprietors had failed to respond to the inquiries of the committee, and after further search in other quarters, I found information unavailable. Not even was a crude approximate available.

MR. SNYDER—I think that a good deal of the secretiveness of steam users, and proprietors of plants, is due to a feeling that they are giving away too much. It is almost the same as going to a manufacturer, and asking him how much it costs to produce a ton of steel, and for that reason, where they do have such data at hand, they rather regard it as stock in trade, and keep it for their own knowledge. I think there is also a feeling that if this knowledge be given to the Engineers' Society, for the use of the general public it may excite unfavorable criticism by comparison with other plants which do better.

I think it would be a wise thing if the Engineers' Society would prescribe some definite method for calculating and arriving at the cost of powers, which might be followed by men who undertake to compile this data in different plants. For instance, if I should undertake to calculate the cost of a boiler horse power per year, the first thing I would endeavor to do, would be to find out the value of the ground which was occupied by the boiler plant, the value of the plant with

the boiler, etc., and the value of the building; on all this I would have to calculate a certain interest on the money invested, and a percentage also for depreciation. As to what that depreciation should be for a boiler house, or iron buildings is a question that I would like to have answered. Also what the depreciation would be on ordinary tubular, or water tube boilers. These are simple instances of the problems which come to the man who has to figure up these things.

I look at this calculation of horse power in this way:— That we can consider three different kinds of energy produced, boiler horse power, indicated horse power of engines, and electrical horse power. At the boiler house, we have to calculate the cost of the boiler horse power per year. This cost would be composed of the cost of the fuel, which would be its cost in the boiler room, together with the fixed charges on the boiler plant, taxes, insurance, etc., and running expenses plus the labor, supplies, repairs, all go to make up the cost of the boiler horse power per year. Then the problem is how to determine the number of boiler horse power generated in one year, and this problem I would like to have some information upon.

If we determine the number of indicated horse power generated by the engine, and also the amount of steam which is used by the engine per indicated horse power hour, we can then calculate back and find out what that steam is worth to generate it and furnish it to the engine. If we can calculate this, and have the cost of indicated horse power, as the cost of our energy for generating our electricity, and want to know the cost of electrical horse power, we simply use the cost of an indicated horse power as a new basis. Again allowing for the charges of interest, depreciation, etc., on electrical machinery, also repairs, labor and supplies, we obtain the cost per E. H. P.

The problem is very frequently of use in determining whether it is economical to install an electric apparatus, replac-

ing small engines. These are points I would like to hear generally discussed. What the depreciation should be considered on buildings, also the depreciation on boilers, engines, etc.; further, if there had been a general answer to the questions sent out, would it have been possible to compile that data, and arrange it in any way that general deductions could be drawn from it. Would it not be simply like endeavoring to arrange a comparison of boiler tests under different conditions, in which case, it is almost impossible to arrive at satisfactory results, and deduce any general law from the comparison?

MR. LEWIS—I imagine any attempt to standardize the depreciation of boilers, boiler houses, engines, etc., would be about as hard as to secure uniformity among coal diggers. They have given that up now and have established a trust.

DR. R. MOLDENKE—I know of a case where an engine was run from the time it was put in, up to the present time, (by the way it was a Westinghouse engine too,) and it has not had one cent's worth of repairs put on it. I know of another engine which depreciated 100 per cent. in three days. It is hard to establish a law which governs this.

MR. CROOKER—In regard to the meager reports which were received, I think the reason the reports have been so meager is that the men do not run them from an engineer's point of view, but from the man's who owns the plant and keeps the books, all he wants to know is what it costs him per annum. He simply keeps his books from his business point of view. It would be to their interest if they knew they were wasting. The reason is that it is not kept from an engineer's point of view.

MR. FISHER—I read an article on the probable cost of electric power in Pittsburgh, and I think the figures were in the neighborhood of \$45 per annual horse power, and that was based on a very large plant of 20,000 to 40,000 horse power supplying a current through cables, conduits, etc., and every-

thing was taken into consideration, the first cost of everything and a sufficient interest on the money and all that. It was somewhere in the neighborhood of \$45 per annual horse power. Referring to Mr. Foster's report he made for the Cataract Co., I find that a great many of the small engines run at a very much increased cost above this, so that for a small plant with fuel as cheap as it is in Pittsburgh it might be cheaper to receive power from a large station. It is interesting to note that for a small building, elevators, and small plants, a large single station could supply the power cheaper than they could run individual small engines.

MR. LEWIS—I believe Mr. Kauffman read a paper on supplying of hydraulic power which was along the same line.

MR. KAUFFMAN—I don't think I gave any figures in that for annual horse power but for intermittent service of that kind, which was cheaper than any other kind.

MR. SNYDER—Is it not a general practice now to determine carefully the cost of power and keep as careful a report of that as is kept in the cost of the product? It seems to me that that is a general practice, and it should be, for if we do not establish a basis for cost, how can we know whether we are improving or not when we make changes. If we make certain changes installing electric power for hydraulic power, how are we to know whether we are saving anything by the change unless we know the cost of each kind of power.

MR. ALBREE—One point in regard to depreciation,—it has been my experience with some of the best pieces of machinery, if it is kept up and if the pieces are replaced as they wear out, the only practical limit to the life of the machine is when some other machine has been invented which is so much better that you throw it out whether it is worn out or not. It is only a question how soon something else will come in to take its place, which will be so much better.

DR. R. MOLDENKE—Could not that question be solved in this way? Charge against that machine an amount correspond-

ing to the interest the capital would have brought if invested in manufacturing; that is, charge the depreciation plus the interest at 15%, for if you put \$10,000 into a plant, you ought to get 15% out of it *per annum*. The question often arises about placing a new machine, will it pay to put it in. A very safe rule is, if it will pay 15% on the cost, put it in, and if not, do not do it. As a general thing I have run my charges for depreciation and interest about 15% of the actual first cost.

MR. WHITED—It is the custom in the old country a great deal more than it is here, I believe, to estimate the actual cost of and running expenses of the plant, and to set aside from the profits of the business each year a sinking fund, the accumulation of which will be sufficient to renew the plant in a certain time. Though a machine may be all right, you cannot afford to use it unless it is up-to-date, and as to a depreciation of buildings that is a thing which is almost impossible to get at. It depends on the pride of the owner. Some men will use a building just as long as it will stand up and keep the rain out, but some others, as soon as the building begins to look bad, will make extensive repairs.

MR. BOLE—Those are questions which have been touched in this report as being matters of book-keeping.

A MEMBER—I would mention that a certain railroad company had for a great many years charged up in their annual inventory the value of the rolling stock, etc., at the original cost.

MR. KAUFFMAN—One thing in the report which strikes me most forcibly is that the cost of fuel and coal which is used is \$7.20 per year per horse power. Also natural gas and gas engines. In a large plant, of course, it shows conclusively that coal is the cheapest thing to use; as long as that condition is in effect I don't see any chance for the Smoke Committee to do much in Pittsburgh.

MR. BOLE—Mr. President, there is just a little correctness and a little incorrectness about that statement of Mr.

Kaufman's. The cost of actual fuel used in a large plant is pretty near an even thing between gas engines and the highest grade of steam engines. But when it comes to the engines and boilers that spoil the beauty of the city by their smoke, most of that smoke is made by very small plants. And when it comes to small plants, a gas engine has a field there which is peculiar to itself, and in that field the small gas engine easily distances the small steam plant in economy. In quite large plants this same statement is pretty fairly accurate; as for instance a steam plant, which using natural gas under boilers, was operated in Bradford, Pennsylvania, furnished the city with lights. It had been using about 52 or 53 cubic feet of natural gas per horse power per hour. They installed gas engines (about 600 horse power) and they cut the gas consumption down to $10\frac{1}{2}$ cubic feet per horse power per hour. It may be said that this is not the best way to use natural gas, but when you are trying to do without smoke, the best way you can eliminate smoke is to use gas engines. In all the incidental cost of power, such as room occupied by boilers, stacks, &c., in labor cost for firing boilers and for handling coal and ashes, in repairs to entire plant and its renewals, and in all the æsthetic aspects of the case the gas engine has unquestioned advantages over the dangerous, dirty and bothersome steam boiler which is the indispensable adjunct of the steam engine.

MR. JOHNSTON—As I understand this report, all of the fuel costs stated, are the costs of the fuel used for steam generators. The committee has not attempted to make comparisons of costs between natural gas used in gas engines and coal used in steam boilers.

MR. BOLE—That is what has been done, Mr. Johnston; the figure I just gave would be 50 to 60 cubic feet of gas as compared with 10 to 12 feet of the same gas.

On motion the meeting adjourned at 9:45 P. M.

REGINALD A. FESSENDEN,

Secretary.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The two-hundredth regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the lecture room of the Society's house, 410 Penn Avenue, Pittsburg, Pa., Tuesday evening, December 19, 1899, twenty-nine members and visitors being present.

The meeting was called to order at 8.45 o'clock, by Mr. W. A. Bole; the President, Mr. Harry J. Lewis, being absent.

The minutes of the previous meeting were read and approved.

For the Board of Direction the following applicants were reported as passed and to be voted upon at the next meeting :

- GEORGE EDWARD HODGE, Chemist,
with Pittsburg Steel Foundry, Glassport, Pa., Swissvale, Pa.
- CHARLES F. McDONALD, - Manager,
Bessemer Dept., Duquesne Steel Works, Duquesne, Pa.
- LOUIS M. McDONALD, - - Foreman,
Con. Dept., Duquesne Steel Works, Duquesne, Pa.

The following gentlemen were balloted for and duly elected to membership :

- F. HARDING BEEBE, - - Draughtsman,
with Julian Kennedy, Pittsburg, Pa.,
5703 Rural Ave., Pittsburg, Pa.
- FREDERICK McD. GODDARD, Electrician,
with George Westinghouse, Pittsburg, Pa.,
6356 Marchand St., Pittsburg, Pa.
- DAVID P. JONES, - - - Consulting Mechanical Engineer,
Room 7, Stevenson Building, Pittsburg, Pa.
- WILLIAM B. MILLER, - - Draughtsman,
with Julian Kennedy, Pittsburg, Pa.,
16 Niagara St., Pittsburg, Pa.

332 ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

WALTER M. McLEAN, - -	Master Mechanic, Works No. 3, Pittsburg Plate Glass Co., Ford City, Pa.
GUY D. NEWTON, - - -	Draughtsman, with Julian Kennedy, Pittsburg, Pa., 3317 Madison Ave., Pittsburg, Pa.
P. K. SLAYMAKER, - - -	Draughtsman, with Julian Kennedy, Pittsburg, Pa., 1507 Federal St., Allegheny, Pa.
JOHN G. SPLANE, - - -	Manager, Pittsburg Dept. of National Transit Co., 323 Fourth Ave., Pittsburg, Pa.

Mr. Ashworth reported for the Program Committee that he had handed to the Secretary the paper for the next meeting.

For the Nominating Committee Mr. Johnson submitted the following report:

Engineers' Society of Western Pennsylvania.

MR. PRESIDENT:—The Nominating Committee beg leave to report the following nominations:

For President, - - -	W. A. BOLE.
For Vice President, - -	C. F. SCOTT.
For Directors, - - -	{ GUSTAVE KAUFMAN; C. B. ALBREE.
For Secretary, - - -	R. A. FESSENDEN.
For Treasurer, - - -	A. E. FROST.

Respectfully submitted,

THOMAS H. JOHNSON, CHAS. DAVIS, T. P. ROBERTS,	} Committee.
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It was voted that an Auditing Committee should be appointed to audit the accounts for the present year. The following members were appointed: Messrs. F. E. House, Chas. Hyde, and H. H. McClintic.

The Secretary reported that the Society had been presented with some photographs of Mr. Watt and Lord Matthew Bolton, of Bolton & Watt, London, England.

A vote of thanks was tendered by the Society to the donor.

The paper of the evening by Mr. W. E. Snyder, of the Schoenberger Steel Company, entitled "Mechanical Devices as Applied to Firing Steam Boilers," was read by the author.

MECHANICAL DEVICES AS APPLIED TO FIRING STEAM BOILERS. ✓

BY W. E. SNYDER.

In an age of manufacturing and in a city that is one of the largest manufacturing centers of the world, the subjects of coal and combustion are always of interest to engineers. To the general public are they also of interest, because of the economic importance of the questions involved. The problem of smoke prevention is simply a problem of good combustion and this, in a steam boiler plant, is dependent on type of furnace and the manner in which it is operated.

In considering the various devices applied to firing boilers, the writer has tried to give truthful and exact statements of experience. If quotations are made the authority is given in every case. It is earnestly hoped that nothing in this paper shall be construed to be either commending or disparaging any particular device. Sincerely believing that the development of true conditions and facts is the work of the experimental engineer, the discussion is given with this alone in view. If unfavorable results have followed the use of any device, they are given; if favorable features have been observed they are stated, as any such statement of a truth should be permitted.

COAL.

In the discussion of the results obtained from various devices for the combustion of fuel, reference is had particularly to the coals of the Pittsburg District.

The general composition of the coals considered may be stated to be from 54 % to 61 % Fixed Carbon and 30 % to 35 % volatile matter. The average proximate and ultimate analyses of ten different samples carefully selected from large amounts is as follows :

F. C.	Volatile Matter.	Total Carbon.	H.	S.	O. & N.	Ash.
57.05%	34.30%	74.35%	4.63%	.97%	11.39%	8.74%

The calorific value as calculated from the chemical composition is 13000 B. T. U. The amount of air theoretically required for the perfect combustion of 1 lb. of this coal is about 10 lbs., of which 64.5% furnishes O to unite with the fixed carbon and 35.5% oxidizes the volatile matter.

COMBUSTION.

Combustion is the chemical process of oxidation occurring rapidly and accompanied by the phenomena of light and heat. In order that a combustible may combine readily with oxygen it is necessary that its temperature be raised. The amount of this raise of temperature is dependent on the nature of the combustible.

The combustion of bituminous coal is a process which may be separated into two parts.

1st. Destructive distillation.

2d. Combustion of the resulting gases and solids.

These processes may occur so closely together as to be almost simultaneous, but they must occur.

The first process does not require a very high temperature and is independent of air supply.

Its products are:

1st. Hydrogen, Marsh Gas, Carbon Monoxide, Olefiant Gas, Benzine, and other Hydrocarbons.

2d. Ammonia and other Nitrogenous Compounds, Volatile Compounds of Sulphur.

3d. Coke and Ash.

The second process, or oxidation requires very high temperature and the presence of sufficient air to oxidize completely all combustible matter. When oxidation is complete its products are: Carbon Dioxide, Nitrogen, Super-heated Aqueous Vapor, and Sulphurous Acid. In practice oxidation is never entirely completed and along with the above mentioned waste gases are small proportions of Hydrogen, Carbon-monoxide, Hydrocarbons, very minute particles of unburned carbon, and some unused air.

In order that the combustion may be as complete as possible the temperature must be very high and maintained steadily so. The only limit to the temperature is the power of the refractory lining of the chamber in which the combustion takes place. The air supply must also be diffused so intimately throughout the combustible matter that each atom of oxygen will find and oxidize its portion of the combustible. This question of sufficient and properly distributed air supply is a particularly important one, because insufficient air means the partial oxidation of some of the combustible, while excess air means lowering the initial temperature, thus conflicting with the first condition of good combustion, and also means heat carried away in uselessly heating a quantity of air from the temperature of the atmosphere to the temperature of the waste gases.

FURNACE ACTION.

A furnace is a chamber in which combustion takes place. In this chamber the combustible and the oxygen of the air unite with the generation of heat. With a given weight of combustible matter burned in a furnace a definite quantity of heat should be generated, which is independent of the time required for the process. It should always be kept clearly in mind that the furnace is a device for the generation of heat and if it does this efficiently, it is a good furnace no matter what becomes of the heat after it is generated.

Various methods have been proposed for measuring the efficiency of a furnace. Evidently the efficiency of a furnace is its efficiency of combustion. That is, if combustible matter be charged into a furnace sufficient to generate 1,000,000 B. T. U. and only 900,000 be generated, the efficiency of combustion would be 90 per cent.

The general practice of comparing boilers and furnaces by the same standard is to be deplored. That the efficiency of a device for generating heat should be measured by the ability of an entirely independent apparatus to absorb heat is

certainly absurd. This practice seems to be especially prevalent among manufacturers of patent grates, stokers, etc., and its erroneous results frequently produce effects, that are absolutely mischievous. The writer has examined the reports of about one hundred trials given in the various catalogues and circulars of patent furnace companies, and in only two was any attempt made to show the character of the combustion. All efforts seemed to be directed to show that a device, designed and sold to burn coal, would boil water. Engineering literature is flooded with the reports of trials of special furnaces in which scarcely any mention is made of the boiler, not to speak of the setting, stack, fuel, proportion of grate surface to heating surface, or special conditions of the trial; and absolutely nothing said about the character of the combustion.

The effects of this practice are apparent everywhere. The utmost confusion of opinion prevails regarding the different patent furnaces. What one man lauds to the skies another condemns in severest terms. Much of this is due simply to the fact that the furnace gets all the blame or all the credit for results, as the case may be. Utterly ignoring the part played by the boiler and its setting in the matter, or the character of the fuel, the furnace salesman points with pride to a large evaporation per pound of coal and demands patronage. Also ignoring such small side issues as boiler and fuel, the owner of a furnace looks at a small evaporation per pound of coal and forms adverse judgment at once. This confusion is increased by men conducting tests who are either careless or incompetent. The results obtained are worse than useless because misleading.

The remedy for this condition of affairs is to have absolutely nothing to do with the results of any trial unless that trial be made by an honest, competent, and disinterested engineer and reported by him in every detail over his signature. Also that every trial be made with the clear idea that the combustion of coal is one process and evaporation of water is

another. Trials conducted in this manner will determine data from which comparisons of boilers and furnaces can be made on rational bases.

To make a comparison of one furnace with another some standard of comparison is necessary, but, as shown in the discussion above, this should not be the evaporation of water.

Dr. Thurston, in his work on Steam Boilers, gives as an expression for furnace efficiency $T_1 - T_2$ in which T_1 , T_2 , and T_3 ,

$$T_1 - T_3$$

are respectively the absolute furnace, stack, and air temperatures. This is clearly not suitable for the practicable comparison of furnaces, because it simply considers temperatures from the standpoint of Thermodynamics and ignores all losses due to incomplete combustion. Also in practice a fair average value for T_1 would be difficult to obtain, while T_2 would be effected somewhat by the proportions, baffling, etc., of the boiler and T_3 is subject to natural variations. For these reasons this law of Thermodynamics cannot be applied to ordinary furnaces working under normal conditions.

In an excellent paper read before the American Society of Mechanical Engineers at their last meeting, by Messrs. Hale and Russell, on Boiler and Furnace Efficiencies, efficiency of combustion is defined as the ratio between the sensible heat generated per pound of fuel and its theoretical calorific value. The sensible heat is given as the sum of that absorbed by the boiler and that carried up the stack by the waste gases. This may be a fair expression for efficiency of combustion, though it neglect the sensible heat carried to the ash pit by the refuse, and also the heat radiated, but it will not serve as a basis for comparing the performance of furnaces, for the reason that a furnace using a large proportion of excess air, which carried a good percentage of heat up the stack would be just as efficient as if that heat went to the boiler and evaporated water.

It has occurred to the writer that a summation of all losses directly chargeable to the furnace would be a rational method

of obtaining a factor which would be of value in the comparison of furnaces.

If we consider an ideal furnace its action is perfect. Nothing goes to the ash pit but incombustible earthy matter, and nothing goes up the stack but the gaseous products of complete combustion. No more air is used than is sufficient to supply the oxygen to unite with the oxidizable components of the fuel. The commercial efficiency of this furnace could be considered 100 per cent., as there is no loss directly chargeable to the furnace.

All furnaces are imperfect and certain losses are incident to their operation. The losses for which the furnace is responsible are the following:

- 1st. Decrepitated coal and unburned carbon in the ash pit.
- 2nd. Excess air in the flue gases.
- 3rd. Unburned hydrocarbons.
- 4th. Finely divided carbon particles or smoke.
- 5th. Carbon monoxide.

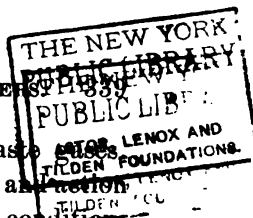
The calorific value of these wastes can be determined as follows:

The refuse from the ash pit can be sampled and subjected to analysis. By knowing the percentage of refuse in dry coal and the amount of unburned fuel in the refuse, the heat lost to the ash pit per pound of dry coal can be very closely determined.

The heat carried away by the excess air will depend upon four conditions:

- 1st. The amount of this excess air present per pound of dry coal.
- 2nd. Its initial temperature.
- 3rd. Its final temperature.
- 4th. Its degree of humidity.

The weight of this excess air per pound of dry coal can be obtained by calculating the theoretical quantity of air required to burn the coal and deducting it from the amount act-



ually present, as shown by the analysis of the waste gases. The quantity of this air will depend on the character and action of the furnace and the manner of firing. This latter condition, however, does not vitiate in the least this method of calculating the heat loss, because if the furnace is of such design that it requires an expert fireman to keep down the excess air, it is an unfavorable feature of the furnace and should be charged against it. In selecting the samples of gas for analysis the setting should be known to be tight, or the samples taken immediately after the completion of combustion in order to prevent the infiltration of air from affecting the result.

The initial temperature of the air is dependent on natural conditions, but correction can easily be made and the tests referred to one temperature as a base. If the air supply be preheated by a device which is a part of the furnace, the heat brought in in this way should be considered in calculating the heat loss due to excess air.

The final temperature of this excess air may be high owing to improper ratio of grate surface to heating surface. To charge this against the furnace is right, as the furnace builder should be held responsible for proper proportions. This excess air will also, when present in large proportions, increase the temperature of the waste gases and cause additional heat to be carried away by the increased temperature of the actual gaseous products of combustion. The actual increase of temperature due to large excess of air, however, is not great and the additional heat carried away as explained may be neglected without serious consequence.

The amount of heat required to heat the vapor present in the excess air can be calculated and considered as a part of the loss due to excess air.

The heat carried away by the hydrocarbons may be determined by a more complete analysis of the waste gases, thus determining the quantity of hydrocarbons present. Their calorific value can then be determined as well as the sensible heat,

which they carry away. As to the actual loss due to this cause opinions differ. Scheurer-Kestner and Bunte report very small percentages present, while Messrs. Hale and Russell give the average loss due to unburned hydrocarbons at about 7 per cent. of the total heating value. Whatever the loss may be in any particular case, careful analyses should lead to a fair estimation of its magnitude.

The heat loss due to the CO can also be determined from the analyses of the waste gases and the sensible heat which it carries can be computed.

In regard to loss due to smoke it is to be regretted that the American Society of Mechanical Engineers does not prescribe a standard smoke scale and method of determining the weight of solid matter discharged from a stack in a given period of time. In this the engineer is left to his own devices, or to follow precedents which have been established by various engineers. When the quantity of solid matter discharged up the stack is determined, a sample can be subjected to analysis and its calorific value calculated.

Each one of these losses should be referred to one pound of dry coal as a basis. Dividing the total loss in B. T. U. per pound dry coal due to the furnace, by the calorific value of the fuel, we obtain the "per cent. furnace loss," a factor which should have large weight in forming comparison and judgment of the action of furnaces.

The following table gives the results of these calculations for five different tests. The losses due to hydrocarbons and carbon up the stack is omitted, as the data taken were not sufficiently comprehensive to obtain these quantities. The results are from different kinds of furnaces and with different rates of forcing. Of course in the actual comparison of furnaces they will be run as nearly as possible under similar conditions. This table is given more to illustrate the method than for the purpose of any comparison of furnaces:

Test.	Boiler forced above rating.	B. T. U. LOSS PER POUND DRY COAL.				Per Ct. of Calorific Value.
		C. in Ashpit.	CO	Excess Air.	Total B. T. U.	
A	00.0 %	630	1385	1421	3436	25 5
B	83.5 "	240	1600	231	2071	15.3
C	46.1 "	899	1533	234	2666	19.5
D	10.0 "	296	149	649	1094	8.1
E	35.5 "	107	236	470	813	6.0

The object of what has been stated is to investigate and indicate all furnace conditions. If the furnace loss is low, indicating good combustion, but a low evaporation is shown by good coal, no blame should be placed on the furnace. The heat generation has been proven efficient; the responsibility for its efficient absorption lies with the boiler.

If it be contended that this method somewhat complicates a boiler trial, it may be answered that this paper does not consider the so-called boiler tests, the ultimate result of which is to indicate the weight of water evaporated per pound of coal during a brief period of time, but refers to trials as conducted by the engineer, who not alone determines evaporative results, but at the same time determines if these results could be improved and the changes necessary to make the improvement.

THE COMMON GRATE.

Having discussed the conditions necessary for good combustion and furnace action it is now necessary to investigate the different furnaces and devices for firing steam boilers. This statement can be made as a truism, not requiring proof: That the device which operates most nearly in accordance with the laws of combustion will give the best results.

The hand fired flat grate will be first considered. Its consideration here is necessary for the proper development of the subject. The laws of combustion have been discussed and

certain conditions necessary for good furnace action have been established. If the common grate fulfills these conditions there is no necessity for the more or less elaborate mechanical devices, but if it does not, the necessity for more efficient furnaces is proven and the employment of some complication in construction is justified.

The flat grate is the most primitive method of firing steam boilers. Its main advantages are simplicity, small first cost and small cost for repairs. Some of the disadvantages are :

- 1st. Large masses of coal thrown on intermittently.
- 2d. The products of the distillation of this fresh fuel heated from below, do not get properly oxidized before they are drawn off up the stack.
- 3d. Large volumes of air are drawn up through the fire cooling the furnace, but not remedying the second evil.
- 4th. The pernicious effects of large volumes of cool air due to the periodic opening of the furnace door while firing, both in cooling the furnace and in disturbing the equilibrium of heat transference.

To illustrate the actual effects of hand firing, the following results are given from two tests, each of nine hours duration and fired by experienced firemen. During each test the number of firings were counted and the time a furnace door was open at each firing, was taken with a stop watch.

During the first test 68 firings were made in nine hours, or about one firing every eight minutes. The aggregate time at least one furnace door was open was 142 minutes, or an average of two minutes and five seconds for each firing. This is equivalent to 181 firings in 24 hours with the furnace open to the air a total time of 6 hours and 17 minutes. During this test there was fired 12,900 lbs. of coal, or an average of 190 lbs. per firing.

During the second test the furnace was fired 70 times, or an average of once every 7.7 minutes. The aggregate time at least one furnace door was open was 174 minutes and 10

seconds, an average of 2 minutes and 29 seconds per firing. This is equivalent to 185 firings in 24 hours with the furnace open to the air 30 per cent. of the time. There was fired during this test 13,300 lbs. of coal, or an average of 190 lbs. per firing.

In a paper read before Des Vereins Deutscher Eisenhütten-Leute at Düsseldorf last April by A. Steinbart, descriptive of an Autographic Gas Composimeter and Pyrometer, an apparatus which automatically records the temperature and percentage of CO_2 in a gas, a set of curves is given which are extremely interesting. They show a continuous record of the temperature taken over the bridge wall, and the percentage of CO_2 in the waste gases of a hand fired furnace for a period of 24 hours. Every change in direction of the one curve has its corresponding change in the other. When the temperature of the furnace dropped there was a similar fall in the percentage of CO_2 . The coal was fired about once per hour and before each firing there was a gradual fall of furnace temperature and also of CO_2 , showing leakage of air as the fire became thin. After a new charge of coal was thrown in the temperature and percentage of CO_2 gradually arose to normal conditions. Careful comparison of these curves shows that analysis of waste gases, not only determines the relative proportion of air present, but also affords an index to the temperature of the furnace.

From the temperature curve the following calculations have been made:

Average furnace temperature considering effect of firing and cleaning fires was 1540 degrees F.

Highest temperature of furnace, 1900 degrees F.

Average temperature of furnace neglecting effect of firing and cleaning fires, 1700 degrees.

Before firing:

Maximum drop of furnace temperature, 900 degrees.					
Minimum	"	"	"	300	"
Mean	"	"	"	580	"

Maximum time temperature fell,	30 minutes.
Minimum " " "	7 " "
Mean " " "	15 " "

After firing :

Maximum time required to regain furnace temperature, 40 min.	
Minimum " " " " "	7 " "
Mean " " " " "	19 " "

Total time furnace was below normal conditions due to firing was 10 hours and 27 minutes, or 43.5 per cent. of entire time.

The percentage of CO_2 dropped from 5 to 8 per cent. at each time of firing, and dropped as low as from 0 to 1 per cent., while fires were being cleaned, showing that combustion practically ceased when cleaning grates.

An examination of these results will show that the common grate does not conform with the laws of combustion. Instead of high furnace temperature and proper air supply, there is fluctuating furnace temperature and large volumes of excess air at times.

Any one who attempts to fire a common grate properly is certainly between Scylla and Charybdis. If he attempt to avoid the evil of large charges of coal he is caught by the evil of having the furnace open to the air more frequently. To fire the common grate economically requires a degree of skill and intelligence united with great physical endurance, that is not common, and where it does exist, commands a remuneration which prohibits its employment in ordinary practice.

This suggests another cause which militates against the use of the common grate. The class of firemen frequently employed in large plants is simply that of the ordinary laborer. The hours are long, the labor is extremely arduous and the remuneration is not large. These conditions restrict the number of men available for the work to those whose abilities are little more than those of a common coal passer. The result is that a furnace which should receive the most careful attention and manipulation receives practically none.

AUXILIARIES AND MODIFICATIONS OF THE FLAT GRATE.

Various devices are manufactured to improve the working of the common grate. Among these may be included various patent bars, shaking and dumping grates, regenerative air ducts, water arches, etc. In many cases these are simply aids to the fireman for slicing and cleaning. The economical advantages derived from their use are extremely questionable. In comparative trials where such patent devices applied to common grates have shown a saving effected, the gain was more probably due to the better care and attention in firing which the patent device demanded. They may be made to show some economy when operated by firemen experienced with such apparatus, but this does not obliterate the fact that when they are accepted by the purchaser they will be operated by firemen of small skill and no experience; nor does it lessen the evil of firing large masses of fuel intermittently with the furnace open to the air while firing.

A very convincing proof that there is no particular advantage in the use of these modifications of the flat grate is that there has never been any general adoption of them. One by one they have been brought into existence with great flourish and in the same succession many have passed into desuetude to give place to something else. Had any one of them possessed really meritorious features it would certainly have been granted a more prolonged existence.

. STEAM JETS.

Another device used to improve combustion is various forms of steam jets and blowers. The use of these, except where used for feeding oil or coal dust, is simply to increase the air supply, and for this purpose they are not efficient nor economical.

In some tests of Steam Blast Apparatus made by J. M. Whitham,* the average result obtained with a steam jet was

* Experiments with Automatic Mechanical Stokers, Vol. XVII. Report of A. S. M. E.

5,820 cu. ft. of air forced into the furnace in one hour per boiler horse power. If the efficiency of a fan driven by a direct connected engine be assumed to be 50 per cent. and the steam per I. H. P. hour be assumed 60 lbs., both of which are safe assumptions, one boiler H. P. hour will force into the furnace, at 2 oz. pressure, 26,200 cu. ft. of air, or about 4.5 times the amount forced in by the steam jet using the same quantity of steam. Or, assuming the same efficiency for a direct connected motor driven fan, and steam consumption of main engine in the power house at 17 lbs. per I. H. P. hour with 70 per cent. efficiency between the I. H. P. of the main engine and the E. H. P. of the fan motor, conditions easily attained in practice, one boiler H. P. hour will force into the furnace at 2 oz. pressure 65,500 cu. ft. of air, or over 11 times the quantity this steam would force in if used in a steam jet.

In addition to robbing the boiler of steam which the jet uses wastefully, the steam it discharges robs the furnace of heat which might be used to evaporate water in the boiler. Every pound of steam discharged into the furnace must be super-heated by heat from the burning fuel and is then discharged at the temperature of the waste gases.

To illustrate the results obtained by using steam jets some notes are given from a trial made by the writer in which the jets were arranged to open when the firing was being done and to close gradually after the furnace doors were shut. The jets were open exactly one-fifth of the time during the trial, yet by actual measurement they discharged 4.8 tons of steam into the furnace in 24 hours. This was equivalent to 12.75 B. H. P. In addition, this steam robbed the furnace of the heat equivalent to 1.8 B. H. P. more, making a total of 14.55 B. H. P., or 4.2 per cent. of the capacity of the boiler was required to operate the jets one-fifth of the time. Had these jets been on continuously, 24 tons of steam would have been discharged in 24 hours, equivalent to 72.75 B. H. P., or

21 per cent. of the capacity of the boiler. Yet this contrivance was sold as a device to increase the economy of steam generation, and an aid in the abatement of smoke.

MECHANICAL STOKERS.

These are devices which feed the fuel to the furnace by mechanical means. If this feeding be done properly and continuously the furnace conditions are preserved more nearly uniform than by hand firing and are consequently more favorable to good combustion.

Opinions as to the actual economy of these devices seem to be much at variance among their users. To illustrate this, the writer will quote from a report compiled by Mr. R. S. Hale for the Boston Steam Users Association in 1897. This report is the result of investigation among firms using stokers to determine the result of their experiences. The following is a synopsis of the results :

Q. Do they save coal? A. 1 Loss, 5 No saving, 6 Saving.

Q. Do they prevent smoke? A. 2 No, 7 Yes.

Q. Do they save labor? A. 1 Increase it, 3 No saving, 8 Saving.

Q. Repairs after two year's use? A. 3 Trifling, 2 No response.

Q. Response to call for steam? A. 5 Slower than hand, 1 Same as hand, 5 Quicker than hand.

Q. Amount of draft required? A. 3 More than common furnace, 4 Same, 1 Less than common furnace.

Q. Further intentions? A. 5 Would put in no more, 3 Doubtful, 6 Would put in more.

No plant could or would report a net gain.

The writer is of the opinion that the causes of much of this diversification of experiences are the following :

1st. No intelligent supervision is exercised over the operation of stokers.

2d. The data as to saving or loss is obtained from persons either prejudiced or incompetent to determine it properly.

3d. Firms using stokers simply do not know whether saving is effected or not. After the novelty of watching a stoker work has ceased to be an attraction, it is simply ignored. Judgment as to results is made up from fuel bills, which may be affected by price of coal, load on boiler plant, and care of stokers and boilers, as well as by the actual performance of the stoker itself.

Saving ought to be effected by using stokers. The nature of their action is favorable to economic conditions. Constant furnace temperature, good combustion and little smoke should effect a gain.

The writer has been privileged to examine a number of curves taken from the Recording Gas Composimeter and Pyrometer mentioned before in this paper, when attached to a stoker furnace. The results are precisely what might have been anticipated from a knowledge of the principles involved. Good uniform furnace conditions are distinctive features. The proportion of CO_2 was very high and its greatest variation in 24 hours did not exceed 4 per cent. except when cleaning fires. Where, in the hand fired furnace frequent and large fluctuation in the CO_2 curve were observed, due to firing, etc., with the stoker furnace, periods of from four to six hours were observed, during which the proportion of CO_2 did not vary 2 per cent. The temperature of the furnace was high and constant. Such conditions could not be otherwise than economical.

CLASSES OF MECHANICAL STOKERS.

The fuel may be fed to the fire in three ways. It may be laid upon the fire, supplied at one edge, or fed underneath. We may divide mechanical stokers into three classes, according to the manner in which the fuel is supplied to the fire and to the path of the gaseous products after distillation.

In the first class the coal is fed to the top of the bed of fire and the gases pass back over the fire on their way to the stack.

In the second class the coal is supplied to the fire at one edge and the gaseous products pass over the bed of burning fuel.

In the third class the fuel is supplied underneath the bed of fire. The gaseous products must first pass up through the fire and then over it.

In the first method the stoker carries the coal in by means of a ram and spreads it over the fire. Many stokers of this type are used in England and on the Continent, but are not common in America if used at all. The objectionable features of firing the fuel on top of the fire are partially obviated by spreading it continuously and in very thin layers.

A series of trials were made in France extending from 1894 to 1897 by a commission of eminent engineers, in which 110 different devices for firing boilers were tried under the same boiler and with the same kind of fuel. No first prize was given but a stoker of this class, Proctor's, an English make, received a second prize. Its principal advantages as enumerated by the judges were that it minimized the work of the firemen and consumed practically all the smoke.

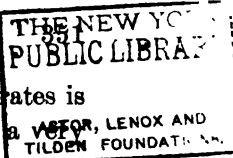
The second class of stokers is by far the more common. It includes the various forms of inclined grates with moving bars and also the endless chain grates. In any of these stokers in which the fuel meets the fire along its edge the zone of low temperature, in which the distillation takes place, is so located that the volatile matters must pass over the bed of incandescent carbon, through the hottest part of the furnace, on their way to the stack. The depth of this stream of gas will, of course, depend on the distance from the top of the fire to the bottom of the boiler. On the lower side is the glowing bed of carbon at a temperature of probably 2500 degrees. On the upper side is the heating surface of the boiler at a temperature of probably 400 degrees. Now these combustible gases, with the suspended particles of carbon, must be wholly consumed in passing across this bed of fire, as it is not probable

that much combustion takes place in the lower temperature of the combustion chamber. The lower strata of gas directly over the fire bed will undoubtedly be fully burned, but the upper strata, especially that which impinges directly on the heating surface and is yielding its heat to the boiler, will be cooled to a temperature at which the small particles of suspended carbon will not be oxidized and they are carried away unburned. More particularly will this be true if the boiler be of the water tube type with the gases traveling transversely across the tubes. In this case the volatile matter is not drawn across the bed of the fire, but much of it rises immediately after distillation and impinges directly against the comparatively cool heating surface with the formation of dense smoke.

If forcing be attempted the fuel will be pushed on the fire before it is properly coked and much of the volatile matter will be drawn over the bridge wall unconsumed. With inclined grates, holes are apt to form in the bed of the fire with a large admixture of excess air and a fall in furnace temperature as a consequence.

Another trouble that is met in burning certain kinds of coal is that the more volatile gases are roasted out, leaving the residue a gummy mass, which absolutely refuses to slide down the grate. It simply clogs on the bars hindering both air and fuel from reaching the fire.

It may be stated as a proposition applicable to this class of stokers that any device with open and moving grate bars cannot, without some special arrangement, burn fine, cheap fuel without an excessive loss in the ashpit. Manufacturers of these machines themselves admit this, and some of them have special arrangements of shelves, etc., underneath by which part of this loss can be reclaimed. The writer has in mind one plant in which this type of stoker was in operation where very serious consideration was given to the plan of installing a few stokers of another kind to burn the refuse from



the ashpits of this class. This dropping through the grates is a continuous waste and in a large plant will amount to a considerable sum annually.

To illustrate this waste in the ashpit the following table is given, of refuse from the ashpit, of several trials made with this class of stoker. Ordinary condittons prevailed during each trial:

Test.	Refuse from Ashpit.	Ash by Analysis.	Difference.
No. 1	18.04 %	10.8 %	7.24 %
No. 2	15.39 "	8.0 "	7.39 "
No. 3	16.3 "	10.8 "	5.5 "
No. 4	17.0 "	9.5 "	7.5 "
No. 5	17.0 "	9.0 "	8.0 "
No. 6	17.6 "	8.5 "	9.1 "

Of these the refuse from No. 2 analyzed 40 per cent. C; that of No. 3 33.8 per cent., and of No. 4 about 35 per cent. The ash from this type of furnace may be considered to average from 20 to 40 per cent. carbon. With chain grates the loss is usually less than this, provided the velocity of the grate be low enough to allow combustion to be completed before the refuse is dropped into the ashpit.

Nearly all stokers of this class work with natural draft. When hard forcing is to be done more coal is fired, a thicker fire carried, and, notwithstanding a stronger draft due to the higher stack temperature, the air supply will in some cases be diminished, causing loss up the stack. To illustrate this the following table is given of gas analyses made during a trial, in which this type of stoker forced a boiler about 40 per cent. above rating.

No. of Sample.	CO ₂	O	CO	N etc.	Excess Air.
1	7.0 %	3.4 %	3.0 %	86.4 %	17 %
2	8.0 "	1.6 "	1.8 "	88.6 "	7 "
3	8.0 "	1.4 "	2.0 "	88.6 "	6 "
4	7.4 "	3.2 "	1.6 "	87.8 "	16 "
5	8.4 "	4.0 "	1.0 "	86.6 "	21 "
6	5.8 "	3.2 "	3.0 "	88.0 "	16 "
7	6.8 "	5.4 "	1.4 "	86.4 "	30 "
8	5.6 "	4.4 "	2.0 "	88.0 "	23 "
9	5.0 "	5.8 "	1.4 "	88.8 "	33 "
Ave.	6.9 %	3.62%	1.82%	81.66%	19 %

The third class of stokers is the one by which the fire is fed from underneath. This is accomplished by a spiral conveyor or a sliding ram, either of which works in a trough with sloping sides. The fuel is pushed in through this trough and rises from thence underneath the fire.

This type of stoker uses mechanical draft and this seems to be one of its most valuable features. Before a discussion of the stoker proper is taken up, it might be well to consider a few of the more important advantages of mechanical draft, which have been developed as the result of considerable experience.

With the extremely variable load of a steel mill or electric plant, flexibility of the steam generating plant is an absolute necessity. During one hour the load will be comparatively light, requiring very little firing to furnish the steam necessary, while probably during the next hour the boilers will be taxed to their limit. Sometimes during an entire day, owing to special conditions existing or to bad coal, the boilers must be forced to their utmost capacity to keep up the pressure. A forced draft meets these requirements perfectly. If the safety

valves blow the fan can be slowed down or stopped if necessary, and if the load increases the draft may be increased and a wide range of conditions met with good economy in every case.

It enables a plant to be operated with comparatively low stacks and is also independent of atmospheric conditions.

A cheaper grade of fuel can be burned with forced draft. This cheap fuel is a mixture of small nut and slack or is all slack. It is so compact that it produces a damping effect when thrown on a fire under natural draft, but the strong air current of a forced blast drives its way through the close mass and maintains a fierce hot fire.

It enables a heavy fire to be carried. This is particularly favorable to good economy and to smoke prevention. A large mass of fuel in a state of rapid combustion within a given space means a rapid evolution of heat per unit of time. An increase in the rate of combustion always implies a decrease in the amount of air per pound of coal. The ultimate result of these conditions is a higher furnace temperature.

The results from the use of mechanical draft in underfeed stokers should not be otherwise than good, because the conditions conform very closely to the laws governing good combustion. The air is discharged in jets on each side of the trough up through which the coal is being forced on its way to the fire. The coal meets the fire and the air about the same time and the distillation process is completed in the low temperature zone under the fire. The products of this distillation must pass up through from 8 to 20 inches of burning fuel, which on the top is a bed of incandescent carbon and then over this bed of carbon on their way to the stack. This is especially effective in completing the oxidation of the combustible elements of the volatile matter before they are discharged into the lower temperature of the combustion chamber. It is of further advantage in preventing the volatile elements from impingeing upon the comparatively cool heating surface of the

boiler until after they have passed through the heart of the fire and have been robbed of nearly all their combustible and smoke-producing elements. The discharge of the air in jets insures a thorough permeation of the mass of fuel by the air and effects complete combustion with a very low percentage of excess air.

A feature of this type of stoker that is at once an advantage and a disadvantage, is the solid cast iron floor of the furnace. The advantage of this is that there is no dropping of decrepitated coal and unburned carbon from the furnace into the ash pit. The disadvantage is that all the incombustible matter of the fuel will accumulate on this bottom and the intense heat of the furnace will fuse it into a solid mass that is extremely hard to break up when cleaning.

The loss of unburned fuel with the ash will be dependent entirely on the care the fireman exercises in burning down and cleaning his fire. All this loss occurs through the furnace doors. As illustrating the loss with the ash with this stoker the following notes are given from results obtained. The first is from a continuous trial of 78 hours fired by inexperienced firemen, with no attempt made to effect any special saving.

The refuse from the ash pit was divided into two parts:

1st. Pure clinkers down to those which would pass through a 2 in. screen.

2d. All the remainder, consisting of small clinkers and unconsumed carbon, which had been drawn from the furnace with the clinkers.

Five samples of this latter part were very carefully selected at intervals and subjected to analysis, showing an average of 70.7 per cent. earthy matter. The first part or large clinker, was 5.01 per cent. of the weight of the dry coal. The earthy matter of the second part was equal to 3.46 per cent. of the dry coal. This shows the total ash from the dry coal to be 8.47 per cent. The ash in the coal as shown by three chemical analyses was 7.87 per cent. This shows a very close agreement between the ash as determined by the analysis

of the coal and that obtained by analyzing the refuse from the ash pit. The actual refuse from the ash pit was 9.89 per cent. of the weight of the dry coal. This gives 2.02 per cent. of the weight of the dry coal, as the weight of the unburned carbon lost in the ash pit. The following gives the comparison of the ash of the coal as determined by chemical analysis with the actual refuse from the stoker from three different boiler trials made under ordinary conditions.

Test.	Refuse.	Ash by Analysis.	Difference.
A	10.9 %	9.9 %	1.00 %
B	9.95 "	8.2 "	1.75 "
C	6.65 "	5.8 "	.85 "

These results show that the refuse from stokers with solid furnace floor does not contain an excessive amount of unburned carbon.

In order to show the character of the combustion obtained in stokers of this class a number of gas analyses are given with deductions made from the same.

From the stack of one boiler 22 samples were selected at intervals during one week. The furnace was working under good ordinary conditions when each sample was taken. Setting old, but in good repair. The following show the extremes and the mean of the entire lot of analyses :

	CO ₂	O	CO	N, etc.	Air per lb. Coal.	Vol. at 62 deg.	Excess Air.
Max.	9.0%	10.8%	0.6 %	79.6 %	18.45 lbs.	242 cu. ft.	84.7%
Min.	14.7 "	2.4 "	0.2 "	82.7 "	10.72 "	140 "	7.0 "
Mean	11.0 "	7.4 "	1.16 "	81.3 "	14.98 "	196 "	49.6 "

To further illustrate the character of combustion obtained with this type of stoker and comparatively new setting, as compared with common grate, and old setting but in good repair, the following tables of analyses are given. In each set of analyses the samples were taken immediately after the gas left the boiler. Each set of analyses gives a fair representation of the furnace action existing during a boiler trial made under good ordinary conditions.

HAND FIRED FURNACE.

No. of Sample.	CO ₂	O	CO	N, etc.	Excess Air.
1	5.7 %	10.2 %	0.8 %	83.3 %	85 %
2	0.0 "	4.0 "	10.2 "	85.8 "	21 "
3	7.0 "	8.4 "	1.0 "	83.6 "	61 "
4	6.0 "	11.4 "	1.0 "	81.6 "	111 "
5	3.2 "	12.0 "	3.6 "	81.1 "	125 "
6	4.2 "	14.8 "	0.2 "	80.8 "	220 "
7	5.0 "	14.0 "	0.2 "	80.8 "	187 "
* Ave.	5.2 %	11.8 %	1.16%	81.87%	116 % .

Air per pound carbon.....31.0 lbs.

Dry gas per pound carbon.....38.5 lbs.

* In making up this average sample No. 2 was omitted, as it was effected by special conditions due to choking of the grates.

STOKER FIRED FURNACE.

No. of Sample.	CO ₂	O	CO	N, etc.	Excess Air.
1	12.4 %	5.0 %	0.6 %	82.0 %	30 %
2	11.0 "	5.8 "	0.4 "	82.8 "	36 "
3	11.0 "	5.6 "	0.6 "	82.8 "	34 "
4	11.8 "	5.4 "	0.6 "	82.2 "	33 "
5	8.0 "	10.0 "	0.2 "	81.8 "	85 "
6	10.0 "	9.2 "	0.2 "	80.6 "	75 "
7	11.6 "	6.2 "	0.2 "	82.0 "	40 "
8	10.2 "	5.8 "	10.2 "	83.8 "	35 "
9	11.0 "	7.6 "	0.2 "	81.2 "	54 "
10	12.0 "	5.4 "	0.2 "	82.4 "	32 "
Ave.	10.9 %	6.6 %	0.34%	82.16%	45 %

Air per pound carbon.....17.7 lbs.

Dry g s per pound carbon.....22.2 lbs.

Samples Nos. 5 and 6 show conditions after cleaning furnace. If we omit these samples the average excess air is 37 per cent.

A comparison of these tables of analyses which are taken from ordinary practice with no unusual conditions will show that the stoker not only maintains more uniform furnace conditions, but also operates with a great deal less excess air than the hand fired furnace.

Regarding the quantity of steam required to operate fan and stokers, Mr. George H. Barrus* gives as the result of one trial, 1.5 per cent. of the total boiler power generated as required to run one fan engine and four stokers.

Three different tests made by the writer during which the steam used to run the fan engine and three stokers was generated in an auxiliary boiler gave from 3.25 to 3.75 per cent. of

* Power of May, 1899.

total power developed as required to operate fan and stokers. The fan engine in this case, however, was somewhat large and did not operate with good economy.

In another installation of 2,000 boiler horse power the blast was furnished by two fans driven by small direct connected engines. Special tests and calculations showed that from 2.4 to 3.0 per cent of boiler power developed was required to operate the fans, and from 1.5 to 1.8 per cent. to operate the stokers.

An installation of the same size in which the blast was furnished by a direct connected motor driven fan, required the equivalent of about 1.5 per cent. of the steam generated to furnish the blast.

DOWN DRAFT FURNACE.

Another device which combines some of the features of the flat grate with the principles of the third class of stokers is the down draft furnace. In the underfeed stoker we have seen that the volatile matter of the fuel passes up through a bed of fire and then over the heap of burning carbon. In the down draft furnace the coal is fired on top of the fire similarly to a hand fired grate. The volatile matter passes down through the bed of fire and then across a burning heap of carbon. The fundamental principle is the same: To burn all combustible gaseous elements and all minute carbon particles before the gases are cooled to a temperature which does not permit ignition.

The path of the gaseous products of combustion in this furnace is such that the furnace resistance is usually high and a strong draft is required to obtain good results. The down draft furnace, however, is commented upon very favorably by many eminent engineers on both sides of the Atlantic.

SUMMARY.

The following statements seem to be justified after a careful and extended investigation of this subject, both theoretically and experimentally:

1st. The phenomena of combustion are governed by certain laws which must be obeyed if good results are to be obtained.

2d. The test of the action of any boiler furnace is the character of its products, solid and gaseous.

3d. It is not possible to work the common grate as used in the ordinary manufacturing plant in accordance with the laws of combustion.

4th. Devices which are used as auxilleries to common grates may, under favorable conditions, be beneficial, but usually simply complicate matters without compensating for the disadvantages of the common grate.

5th. Mechanical stokers should affect a saving over common grates, but in some cases this saving may be neutralized by certain losses coexistent with the operation of the stoker.

6th. The failure of mechanical stokers to produce satisfactory results is probably due more frequently to inattention on the part of superintendents, carelessness on the part of the men who operate them, or a dense ignorance of the entire subject of combustion on the part of all concerned, than it is to actual defects in the principal or action of the machine itself.

7th. Owners of boilers plants should be keenly alive to the fact that the subject of combustion is an extremely important one and that the initial step in the process which will transform black blocks of inanimate matter into living force, obedient to the will of man, should not be relegated to the intelligence of the ordinary labor class, nor to the practical man, who is sometimes so intensely practical that he refuses to recognize the inviolable laws of Nature ordained by an All-wise Providence: but, that it should be entrusted rather to the supervision of the intelligent engineer, whose comprehension of principles makes him independent of the details of special plants, and enables him to direct all so that saving is made

where waste existed, and loss is changed to gain, the ultimate effects of which is to augment the economic prosperity of this Nation.

MR. BOLE—We have listened to a very interesting paper and one which must have given the author a great deal of work.

MR. ASHWORTH—I believe that we all agree in the idea that this is a very elaborate and exhaustive paper, and I think that the Society should be very proud to have it on its records.

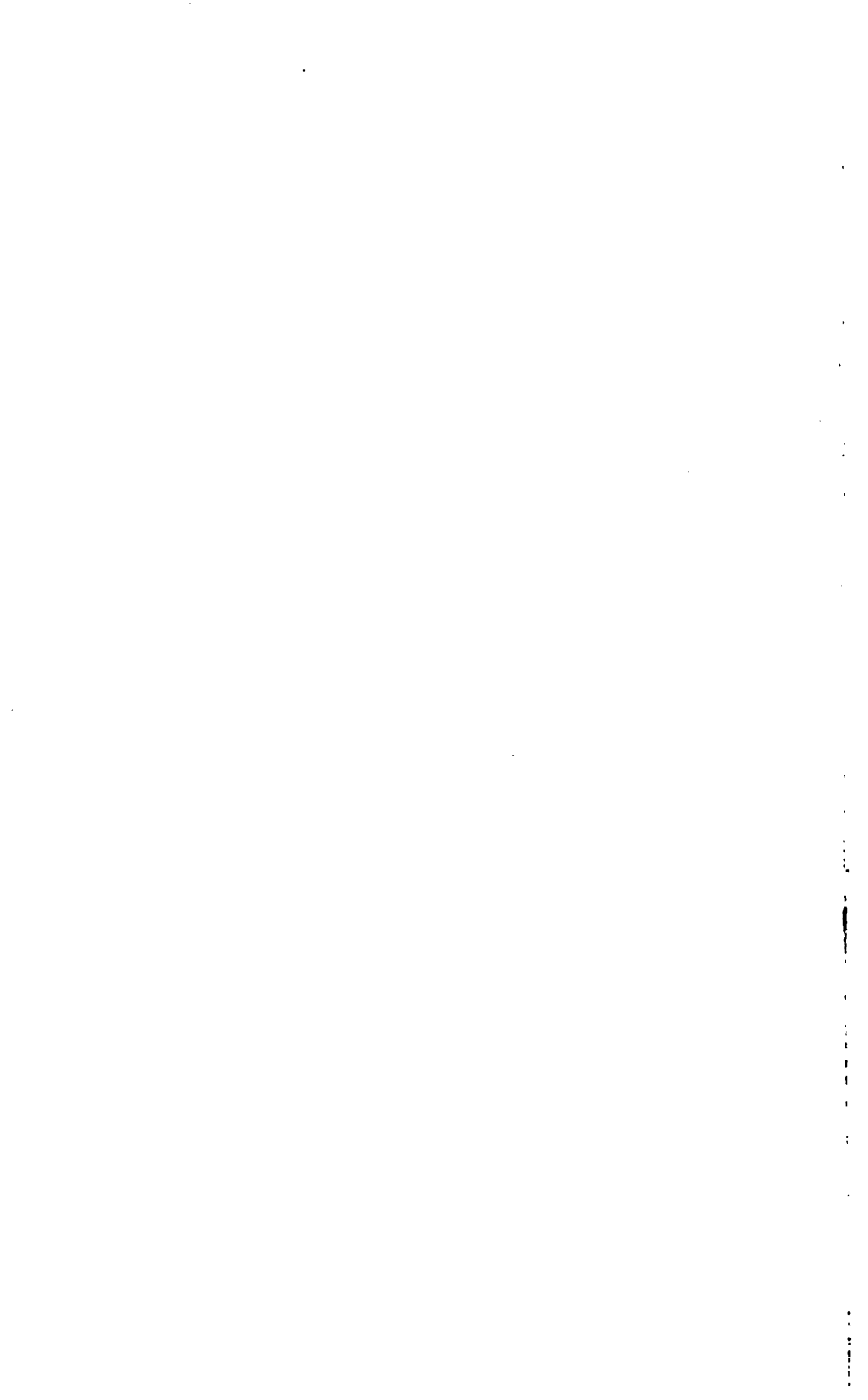
It was moved and seconded that a vote of thanks be tendered Mr. Snyder for his splendid paper. (Motion carried.)

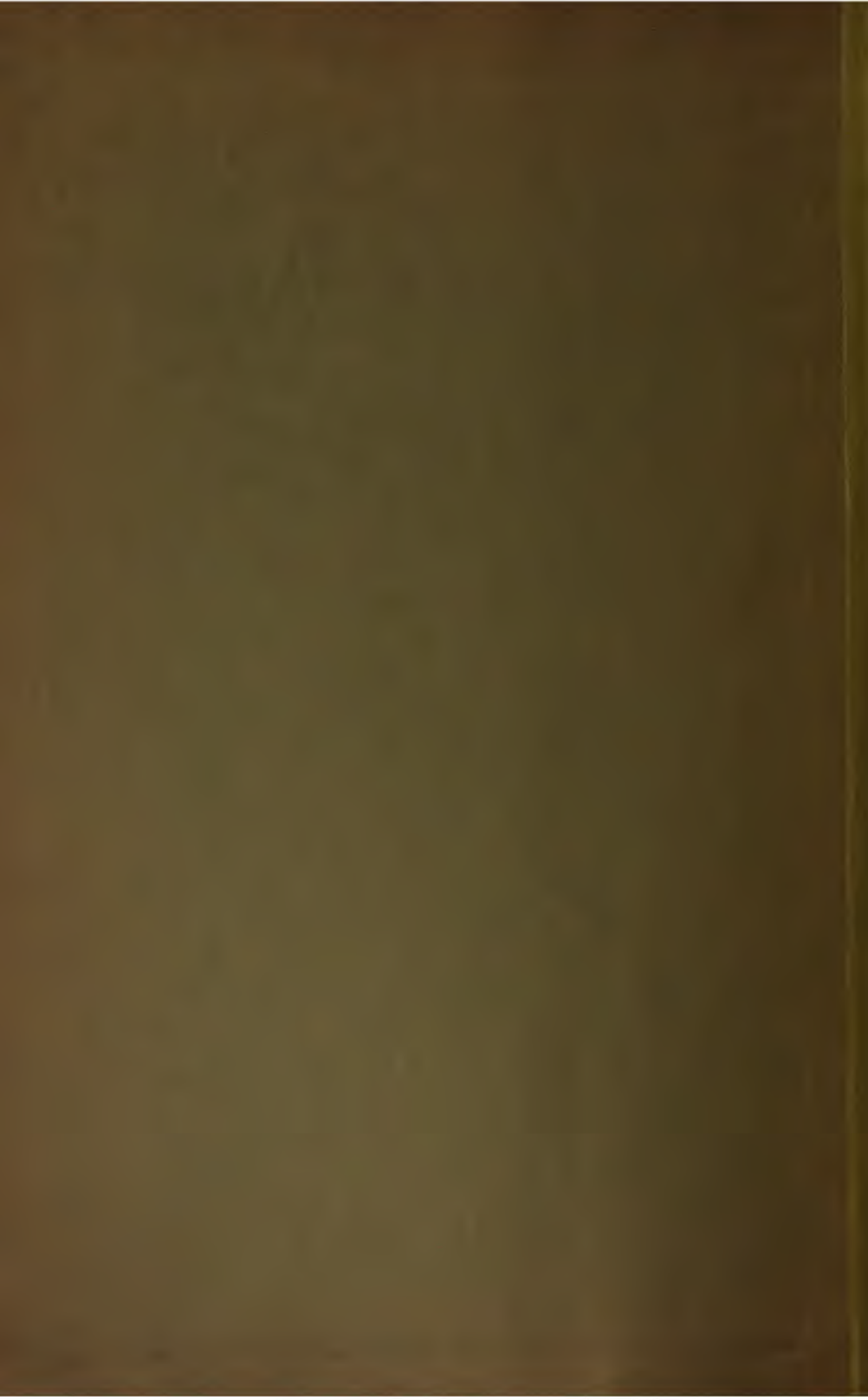
MR. BOLE—This is a paper which cannot be very well discussed on the spur of the moment, and I doubt if it can be satisfactorily discussed by any one here until we have seen it in print. However, if any one has any remarks to make, we would be glad to hear them.

On account of the lateness of the hour, it was voted that the discussion of the paper be deferred until such time as the Program Committee could find a place for it.

On motion the Society adjourned at 10.10 P. M.

REGINALD A. FESSENDEN,
Secretary.





JAN 13 1936

